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STUDY CONCERNING RAT-BITE FEVER IN MANILA, PHILIPPINE ISLANDS [1]

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[1] Presented for publication July 1, 1932.

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INTRODUCTION

It has been proved beyond doubt that rat-bite fever exists in Manila. The demonstration of the specific parasite that causes this disease in a patient, as reported by Ana Vazquez-Colet,[2] gave to the previous clinical reports sufficient weight to justify the statement that this disease has been endemic in Manila for many years. In view of the absence, in the past, of any systematic study of the conditions in Manila, with regard to rat-bite fever, the senior author projected a series of studies with the view of studying the biology of *Spirochæta morsus muris*, particularly with regard to its behavior in the body organism, immunity, hæmatology, transmission, and chemotherapy. Although these investigations have not exhausted the problem in all its details, the report, being the first of its kind that comes from Manila, gives a useful idea of the basic conditions existing at present in that city.

Besides the phases of the problem already mentioned, a comparative analysis was made between the distribution, throughout the City of Manila, of human rat-bite fever and that of plague, observed during the outbreak which occurred in Manila twenty years ago.

The senior author outlined the plan of the experiments, particularly those concerning the immunity as tested by superinfection and reinfection, as well as the chemotherapeutic experiments. The actual experiments on animals were carried out by Dr. H. Hirano, who has had a wide experience with this disease in Japan. The treatment of the two patients by specific drugs was given by Dr. Ana Vazquez-Colet, who is personally attending to the administration of antirabic treatment and who found all of the cases reporting at the Bureau of Science, making the diagnosis on clinical grounds and history. The isolation of the strains from the patients was carried out by Dr. H. Hirano. Thus the clinical diagnosis was confirmed.

[2] Philip. Journ. Sci. 46 (1931).

Dr. T. Corpus, of the Philippine Health Service, kindly assigned to us for study the cases that he encountered and diagnosed clinically in his health district. The hæmatological study on monkeys inoculated with rat-bite fever and that of one patient was carried out by Dr. José Ramirez. On his arrival in Manila, March 29, 1932, Dr. S. Arima continued the work of Dr. H. Hirano, who was recalled to his home country.

EXPERIMENTAL PROCEDURE

Unless mentioned otherwise the experimental animals were inoculated by intradermal inoculation. It was the purpose to produce a local lesion first, before the septicæmic stage set in, so as to approximate, in experimental animals, as much as possible the course of the disease as it occurs in man. Following the inoculation, the animals were inspected daily and their temperatures were recorded. Dark-field examinations were made at frequent intervals of time.

THE STRAINS OF SPIROCHÆTA MORSUS MURIS EMPLOYED

The strains employed in this study have been isolated by the authors from patients who acquired the disease in Manila. The first strain was obtained from a little Filipina, who had been bitten on the forehead by a rat at her residence in San Nicolas district in Manila.[3] This was the first case on record of rat-bite fever in the Philippines in which the etiology of the disease has been definitely proved through demonstration of the causative agent in the patient and in the experimental animals that were inoculated with the material obtained from the patient.

Shortly after this case was found by Doctor Vazquez among the patients applying at the Bureau of Science for preventive antirabic treatment, another case was found by Dr. T. Corpus, of the Philippine Health Service, in charge of the Meisic Health Station, Manila. The patient was sent to us for laboratory confirmation of his clinical diagnosis of rat-bite fever.

The patient was a young adult Filipino, a fireman by occupation, who resided in the same San Nicolas district as the first patient did. He exhibited typical local initial lesion on the finger and subsequent lesions on the arm as well as general manifestations of rat-bite fever.

[3] Vazquez-Colet, Ana, Philip. Journ. Sci. 46 (1931) 159–165.

The third case was found by Dr. Ana Vazquez-Colet among patients reporting for antirabic treatment at the Bureau of Science treatment station. It concerned a young Filipino man. (See stibosan in treatment of rat-bite fever, page 16.)

The fourth case was a 6-year-old Filipino boy in whom the clinical diagnosis was made by Dr. T. Corpus, of the Philippine Health Service. The doctor sent the patient to the Bureau of Science for laboratory confirmation of his clinical diagnosis, which was confirmed. The patient resided in Tondo.

The fifth case was a young son of an American residing in Paco district. The patient had been under treatment for some time before he was referred to us for laboratory diagnosis. (See stovarsol in treatment of rat-bite fever, page 13.) In a short time, one case in a small child residing in Quiapo district and two cases of adults residing in Intramuros, Manila, followed.

One more case was found in a child, in the vicinity of Tutuban Station. In March, 1932, another patient, a female adult suffering with rat-bite fever, reported for treatment. This case contracted the disease in Del Pan, a street that runs through San Nicolas district between the river and the bay shore.

May 12, 1932, a 50-year-old Filipina was sent to the Bureau of Science laboratory for Pasteur treatment. She had been bitten by a rat on the hand and exhibited typical primary and subsequent lesions as well as general symptoms of rat-bite fever. The patient contracted the disease at her residence, No. 322 Cabildo Street, Intramuros, more than two weeks previous to reporting for treatment.

SUMMARY

In the course of one year, 1931–1932, eleven strains of *Spirochæta morsus muris* were isolated from patients suffering with the disease and residing in Manila.

VIABILITY OF SPIROCHÆTA MORSUS MURIS

The experiments concerning the viability of *Spirochæta morsus muris* were arranged in such a way that measured quantities of blood of inoculated guinea pigs in which spirochætes were present, as demonstrated by the dark-field microscope, were diluted with sterile citrated salt solution and kept at various temperatures. From time to time, normal guinea pigs were inoculated with the salt-solution-blood mixture. After

several experiments in which we attempted to find out the proper amount of inoculum to be used, the experiment proper was performed and the results are shown in Table 1, page 47. From this table, it follows that under the conditions existing during the experiment, the spirochætes remained viable for at least eight hours, while in no instance were they found viable twenty-four hours or more after the blood has been removed from the infected animals. It may be seen also from the table that the temperature at which the infected blood was kept had no appreciable effect on the viability of the parasites in question.

CLINICAL MANIFESTATIONS OF RAT-BITE FEVER IN PHILIPPINE MONKEYS

The clinical picture of rat-bite fever varies in individual animals according to the severity of the infection and is largely dependent upon the mode of inoculation. A composed picture of clinical manifestations developed to a full extent in one and the same animal, what may be called "a classic case," consists of the following symptoms: (*a*) Initial local manifestation, (*b*) subsequent or regional dissemination of the infection, (*c*) general manifestations, (*d*) fever, and (*e*) exitus.

LOCAL MANIFESTATION OF RAT-BITE FEVER

A few days after intradermal inoculation of *Spirochæta morsus muris* the primary local lesion develops. Its intensity may vary to a certain extent, but it appears with great regularity and its incubation period is definite and quite constant. The first sign of the primary lesion is an elevated induration at the point of inoculation. It soon becomes surrounded by an œdematous area which gradually spreads, extending to the upper lid if inoculation was performed on the eyebrows. The œdema is at times so intense that a well-marked ptosis of the corresponding lid results. The œdematous swelling soon assumes a characteristic purplish blue tinge, which is particularly noticeable, even to an inexperienced eye, by comparing it with the white skin surrounding the eye of the Philippine monkey when unilateral inoculation into the eyebrow is practiced. The development of the primary lesion from the beginning to the full development lasts for some time. Regression starts in the center and rapidly spreads over the entire affected area. The œdema flattens and a more or less pronounced branny desquama-

tion and suggestion of alopecia are noticeable. The primary lesion heals without scars, and sooner or later during the development of the primary lesion, the original induration within the œdematous area, is found to be covered with a thin, slightly moist crust.

SUBSEQUENT OR REGIONAL DISSEMINATION OF THE INFECTION

A. LYMPHOGENIC OR REGIONAL METASTATIC LESIONS

(*a*) From the primary lesion the process spreads into the surrounding skin, following the lymphatic stream. Within the œdematous area new flat indurations form, which in turn become covered with a thin, slightly moist scab. This occurrence is not limited to the original œdematous area, that is to say to the eyebrow, but similar lesions spring up apart from the region of the original primary lesion. They may and frequently do form on the lower orbital margin, on the nose, or in the zygomatic region of the face. In such a case they represent flat, round, or oval indurations surrounded with a narrow œdematous area which is far smaller than that of the primary lesion. They, too, like the primary induration proper, become covered with a crust. The lesions under discussion are restricted to the side of the face on which the inoculation was performed, in other words they are not symmetric but unilateral, rarely crossing the middle line, which happens at times at the meeting point of the eyebrows.

(*b*) Frequently only slightly suggested, but at times pronounced, a diffuse purplish blue exanthema in the face or on the anterior surface of the neck was observed. This exanthema is located apart from the lesions just described, is most pronounced in the central part of the affected skin area, and gradually vanishes into the normal skin. This exanthema is more evanescent than the lesions described above.

(*c*) Regional lymphadenitis is encountered at times to such a degree that the lymph nodes are distinctly enlarged on palpation, while at other times, though palpable, it is difficult to ascertain definitely their enlarged condition by mere palpation.

GENERAL MANIFESTATIONS

Of the general symptoms of rat-bite fever in Philippine monkeys, the following were noted: (*a*) Fever, (*b*) general lymphadenitis, and (*c*) diarrhœa.

Fever.—The fever observed in Philippine monkeys that were infected with *Spirochæta morsus muris* by intradermal injection is of the remittent type. Soon after the inoculation, the temperature shows a slight rise followed by a drop. The temperature curve remits, climbing to the highest peak usually on the ninth day after intradermal inoculation, after which day the temperature gradually declines, following the remittent type. Before it reaches normal it shows several elevations, preserving the general type of remittent fever. In case of a lethal infection, the temperature crosses the normal line and continues dropping for several days before exitus.

General lymphadenitis.—In a few monkeys infected with rat-bite fever distinct, palpable, lymph nodes were noted in parts of the body remote from the point of inoculation in animals in which glands were found normal at the beginning of the experiments.

Diarrhœa.—Not infrequently during experiments with rat-bite fever on Philippine monkeys, as a symptom of general infection, distinct diarrhœa was observed. Its occurrence in the course of the infection coincides with the febrile stage. It was usually of catarrhal character, but frequently a considerable amount of mucus and blood was observed. This observation was supported by the autopsy findings. Without exception, hyperæmia of the intestines and enteritis of the septicæmic type were encountered post mortem.

CLINICAL MANIFESTATIONS OF RAT-BITE FEVER IN GUINEA PIGS AND RABBITS

THE INITIAL AND SUBSEQUENT SKIN LESIONS IN GUINEA PIGS AND RABBITS

As in monkeys, so in guinea pigs and rabbits, the initial and the subsequent lesions were typical. The initial lesion was characterized by soft swelling, a papular efflorescence. It increased in size and spread on the periphery. As in yaws it commenced to heal and flatten in the center. When the initial lesion reached a certain size there developed a desquamation on the surface of the lesion and the formation of scabs. Rarely an ulcerative lesion formed in the center of the initial lesion.

The subsequent lesions sprang up around the initial lesion. They were much smaller than the initial lesion and more superficial, showing a good deal of desquamation and frequently were covered with superficial dry scabs.

Of the general lesions, alopecia, lymphadenitis, fever, desquamative blepharitis, and even an inflammation of conjunctiva and cornea were observed. These were late lesions, and spirochætes were not found in them. They healed on specific treatment and were coincident with the general atrophy of the experimental animal's body. The variety of lesions experimentally produced by inoculations with rat-bite fever makes guinea pigs and rabbits desirable animals for experimental study of this infection. We have noticed no advantage, in this respect, of the monkey as an experimental animal over the guinea pig or the rabbit.

THE INVASION OF THE BLOOD STREAM BY SPIROCHÆTA MORSUS MURIS IN PHILIPPINE MONKEYS

The invasion of the blood stream by spirochætes in the Philippine monkey appears to be intermittent. The number of spirochætes in the circulating blood at any time was very small. In no case was it possible to detect the presence of spirochætes in the circulating blood by repeated and thorough dark-field microscope examinations. In order to demonstrate the parasites in the circulating blood, inoculation of guinea pigs and white mice with the blood of infected Philippine monkeys had to be resorted to. Following this procedure, which may be termed an enrichment process, we were able to demonstrate the fact that *Spirochæta morsus muris* invades the blood stream of Philippine monkeys. The majority of the monkeys were inoculated only once, while two of them (Syp–25 and J–11) had been superinfected and samples of blood were used to inoculated guinea pigs and mice. It was found that the blood of monkeys that were bled during the early period of infection harbored at times demonstrable spirochætes. In monkeys in which the infection had lasted for a long time, the specific parasites could not be found in the blood stream. In this particular experiment the dividing line was about sixty-nine days in a superinfected animal. Below this time limit and including the sixty-nine days, the spirochætes were demonstrated to be present six times in nineteen trials. Samples obtained from monkeys that had been infected for more than sixty-nine days, that is to say in seven instances, the transfers of blood to susceptible animals were invariably negative.

It follows from these findings that in Philippine monkeys the spirochætes invade the blood intermittently during the early

stage of the infection and that after the infection has lasted for some time, in our case about two months, they no longer can be demonstrated in the blood stream.

THE INVASION OF THE BLOOD STREAM BY SPIROCHÆTA MORSUS MURIS IN GUINEA PIGS

In guinea pigs the study of this manifestation of rat-bite fever infection can be more easily pursued than in monkeys, since the parasites occur in the circulation of guinea pigs in sufficient numbers to be detected microscopically. Thus, the study becomes technically simple, particularly when a dark-field microscope is used.

The time between the intradermal or subcutaneous inoculation by viable and virulent spirochætes and their first occurrence in the circulating blood averaged, in our experiments, seventeen to eighteen days. Eight days was the shortest, and thirty-nine days the longest, time that elapsed between the inoculation and the appearance of the parasites in the blood of these experimental animals. The occurrence of the spirochætes in the blood stream is intermittent, and the number of them encountered at various times is variable. If the animal succumbs to the infection in the very acute stage, they persist in the blood stream to death. In those instances where infected guinea pigs survived the acute stage, the periods of negative findings separated by positive findings became longer the longer the animals lived. Thus the phenomenon of gradual disappearances of the spirochætes from the blood stream in the course of the infection that was indicated in the findings on monkeys is more pronounced in the case of guinea pigs.

CHEMOTHERAPEUTIC EXPERIMENTS WITH PHILIPPINE STRAINS OF SPIROCHÆTA MORSUS MURIS

In a publication in which P. Uhlenhuth and V. Seiffert[4] discuss the results of recent studies along the lines of experimental antimony therapy, the following statement is found: "Of particular significance, however, is the specificity which is observed again and again in experiments with various antimony-preparations." And further: "Only an experimental investigation arranged in many directions can discover the specific efficacy of chemotherapeutics."

[4] Klin. Wochenschr. 10 (1931) 1755.

We have felt, likewise, that further experimentation on chemotherapy is highly desirable and the above statements, coming from such a competent source, have encouraged us to publish the results of our experiments with regard to the chemotherapy of rat-bite fever. This is done in particular for the reason that the Philippine strains have not been studied hitherto, and although other experimental results point to the expectation that, as in other respects, in chemotherapy the Philippine strains will behave in very much the same way as do other strains of this particular spirochæte, experimental evidence is always reassuring and not out of place.

Our chemotherapeutic experiments concern guinea pigs, rabbits, and Philippine monkeys. Of the arsenicals, neosalvarsan and stovarsol were used. Antimony was represented by antimosan, stibenyl, and stibosan. Bismuth was used in the form of quinine-iodo-bismuthate, mercury as mercury salicylate. The chemotherapeutics concerned were tried partly as treatment of already infected animals, partly as preventatives; that is, the drugs were administered before the disease broke out in experimentally inoculated animals.

EXPERIMENTS CONCERNING CHEMOTHERAPY OF RAT-BITE FEVER

Guinea pigs of approximately the same weight were inoculated with a Manila strain of rat-bite fever. The spirochætes were found repeatedly in the blood of the inoculated animals. Thus we were assured that the inoculation resulted in a successful infection. The animals were then treated with the various drugs, and the blood examination by means of the dark-field microscope and stained slides was continued. Two drugs used in these experiments gave satisfactory results.

Neosalvarsan, the effect of which upon *Spirochæta morsus muris* is well established, gave undoubtedly the best results. In successfully infected animals that were treated with neosalvarsan, the spirochætes disappeared from the blood stream. The examinations were made from the third to the thirtieth day after the treatment. Stibosan is another drug that showed marked effect.

Using the other drugs—that is, quinine-iodine-bismuthate, antimosan, and mercury salicylate—the results were doubtful. Likewise, stibenyl showed no effect upon the spirochætes in the blood stream; on the contrary, not infrequently, a striking in-

crease of spirochætes in the blood stream of animals treated with this drug was noticed.

Taking the excellent effect of neosalvarsan upon the rat-bite fever infection as well established, we have extended our experiments with stibosan in search of further information with regard to its effect on rat-bite infection.

The effect of drug treatment on the temperature curve of guinea pigs infected with rat-bite fever was quite evident. Not only those drugs that brought about permanent disappearance of the spirochætes from the circulating blood but also some of those that failed to do so showed an effect on the temperature curve in the same direction. The immediate effect is a sudden drop of temperature. This drop may be very abrupt as can be seen in M–22 (neosalvarsan) and in M–32 (stibosan). The higher the fever, previous to treatment, the deeper appears to be the dip of the temperature curve. It sometimes drops below normal and suddenly returns only to continue, at a lower grade, the same type of curve that it did before treatment. A slightly pronounced, but similar effect was noticed when treatment with bismuth (M–36) and even with mercury (M–46) was given. This phenomenon—that is, the drop in the temperature curve, was found constantly only in those animals that, having been infected, were treated particularly with either neosalvarsan or stibosan. An effect similar to that of successful chemotherapy on the temperature curve can be seen in the animals that were treated when relapse occurred or reinfection was performed.

This effect of the drugs concerned upon the drop of body temperature was absent when the drugs were injected to normal healthy animals of the same kind.

EXPERIMENTS CONCERNING PREVENTIVE CHEMOTHERAPY OF RAT-BITE FEVER

The experiments were arranged in such a way that the animals, when infected, received at the same time one intramuscular injection of the respective drug in an appropriate amount. No further treatment, aside from the first injection, was given. The animals were approximately of the same body weight, from 270 to 370 grams. The animals were kept under observation for three months, and daily examinations for spirochætes were made. With each group inoculated, one normal, untreated guinea pig was also infected and served as a control of viability of the inoculum.

From this experiment, which completes the preceding one, it follows that of the drugs tested (mercury salicylate, stibenyl, antimosan, quinine-iodide bismuthate, and stibosan) stibosan was the only one that showed marked effect as a preventative against rat-bite fever infection.

In view of the high efficacy of stibosan towards *Spirochæta morsus muris*, as a therapeutic and preventative, an experiment was arranged in which stibosan in measured dosage was given intramuscularly and infection was performed sometime later. It was desired to know, approximately, how long the protective power of the stibosan injection would last in guinea pigs. It was found that the preventive protection of stibosan against rat-bite fever lasts between two and three weeks, depending on the dose of the drug per unit of body weight.

DISCUSSION

In an extensive work on the chemotherapy of rat-bite fever in white mice, Schlossberger [5] enumerated a long series of drugs that gave negative results. Among others, the author mentioned antimosan, stibenyl, and stibosan. He claimed that complete sterilization of mice was only obtained by the use of arsenicals; such as, stovarsol, sulpho, and neosalvarsan. Our results of experiments agree with those of Schlossberger with regard to antimosan and stibenyl; however, stibosan gave at our hands promising results.

On the other hand Schockaert [6] claims that stibosan gave satisfactory results in his experiments with rat-bite fever. These differences of findings may be due to the fact that different experimental animals may have been used or that the strains of *Spirochæta morsus muris* employed by various authors showed differences in their susceptibility to this drug. It may also be mentioned that stibosan must be used in freshly prepared solutions in order to give the desired effect on the particular spirochætes. If the solution of stibosan is allowed to stand at room temperature for twenty-four hours or if it is heated, the effect of the drug may become equal to that of stibenyl; that is to say, nil. It may be well to remember that the difference

[5] Ztschr. f. Hyg. u. Infectionskrankh. No. 4 108 (1928) 627–636, July 3.

[6] Antimontherapie im Rattenbissfieber. [Antimony treatment in rat-bite fever.] Deutsche Med. Woch. 57 (January, 1931) 103–104. (16 refs.) (Bact. Inst., Univ. Lowen.)

in the chemical composition of stibosan and of stibenyl consists in the presence of one chlorine in stibosan. Our experiments with stibosan, on sixteen guinea pigs that survived long enough after the treatment to allow conclusions, invariably gave satisfactory results. That is to say, in guinea pigs the spirochætes, which were found in the blood of the animals previous to the treatment, could not be demonstrated there after one injection of stibosan and the animals lived.

These therapeutic results with stibosan have been confirmed by the results of preventive therapy of rat-bite fever with the same drug.

A HUMAN CASE OF RAT-BITE FEVER TREATED WITH STOVARSOL

The use of arsenical preparations in the therapy of human rat-bite fever is well founded. That the Philippine strains of *Spirochæta morsus muris* are amenable to the effect of arsenicals is evident from the early publications of Guerrero and Montes as well as from the recent observations made by Dr. Ana Vazquez-Colet.

It may be desirable at times on the part of the physician or on the part of the patient to avoid injections, in which case arsenicals administered by mouth must be considered. It was, therefore, attempted to find out the possibilities of this kind of treatment in chemotherapy of human rat-bite fever. One case treated with stovarsol is reported herewith.

HISTORY

November 16, 1931.—E. Laird, 13 years old, male, residing at 21 Mindoro, Paco, Manila. About two months ago woke up in the morning and felt pain over the right eyebrow. He noticed on the right eyebrow a bite the size of a pin prick. Some time later the place of bite became sore. The patient scratched the sore place, and a swelling developed. The next day the swelling extended also on the opposite eyebrow. It persisted until the present time. The patient entered St. Paul's Hospital Oct. 9, 1931, and was discharged Oct. 14, 1931. He returned to the same hospital Nov. 4, 1931, and was discharged Nov. 11, 1931. The patient was treated by hot compresses applied to the lesion. While in the hospital the patient was taking some liquid medicine by mouth. Each time the patient stayed in the hospital the lesion improved under treatment.

Present condition.—The patient weighs 37.2 kilograms. Temperature by mouth 37.6° C. at 11.00 a. m. Pulse 120. General condition good. On the left half of the face there is a distinct swelling surrounding the left eye completely and partially closing the left eye. The swelling is spreading over the left cheek. The preauricular region is distinctly elevated, and there is a considerable swelling under the ear in front of the

upper insertion of the sternocleidomastoid muscle, gradually diminishing down towards the clavicle, but it is still noticeable in the supraclavicular region. In the swollen region there are palpable superficial lymph nodes, hard and large, following the anterior margin of the muscle. Small lymph nodes are perceptible on the posterior margin of the muscle. Nothing abnormal in the axillæ and plica cubiti. Patient complains at present of no pain. The affected parts are firm to the touch and show a pinkish discoloration of the skin contrasting with the light complexion of the rest of the face. On the upper margin of the left forehead, near the hair line, there is a conspicuous, elevated, rather red, lymphangitic, wavy line about 2.5 cm long and 2 mm wide, and in the space between the eyebrows there is a distinct, pink, maplike, slightly elevated maculo-papulous efflorescence about 1 cm in diameter. Under the outer half of the left eyebrow there is a distinctly palpable induration of the skin about 1 cm. by 0.5 cm.

November 17, 1931, 3 p. m.—Temperature by mouth 38.6° C. One-half tablet stovarsol, dissolved in a small quantity of water, was administered by mouth. Leucocyte and differential counts were made by Ramirez (postea). Urine findings normal.

The left upper and lower eyelids have acquired a purplish discoloration. A rounded, pink, papulo-macule, about 0.75 cm in diameter has developed on the right cheek by the nostril which is quite firm to the touch. Papulo-macules about 0.5 cm in diameter have also appeared below and behind the left ear. A maplike area, about 2 by 1 cm, delineated by a fine lymphangitic line, has appeared on the left side of the back of the neck. The lymphangitic line on the forehead still persists, being slightly redder and wider than before. The posterior, superior, cervical, lymphatic glands are swollen.

Tissue scrappings were obtained from an incision made into one of the maculo-papules and typical spirochætes were found in smears stained by Giemsa's method.

November 18, 1931.—The patient was seen at his home because of high fever. Temperature by mouth 40.1° C. Pulse 122. Urine normal.

Left eye is closed and the affected parts are swollen and intensely red. The papule on the right cheek and the one between the eyebrows, below and behind the left ear, persist and are firm to the touch. The upper eyelid is indurated. The superficial cervical glands are greatly swollen and hard. The posterior cervical glands are swollen. A lymphangitic line about 2 mm wide and irregular in its course, extends from the middle of the left lower lid, down the neck, to the left clavicle. Reddish blotches are present, here and there, on the left lateral and posterior portions of the neck. The lymphangitic line on the forehead, described previously, is not visible now, but another one has appeared on the scalp, following the hair line on the left forehead and temple. Over the affected parts of the skin, which is now intensely red, small irregularly shaped patches of light skin are visible. The rest of the body shows nothing abnormal.

November 19, 1931, 2.30 p. m.—Patient came to the Bureau of Science. Temperature by mouth 37.4° C. Pulse 97. All the redness has gone, except on the left upper eyelid. This eyelid, especially towards the eyebrow,

is indurated. The left eye still appears much smaller than the right one. The swelling of the glands has greatly subsided. No reddish blotches, no lymphangitic lines are visible anywhere. The papules on the right cheek, which were visible yesterday between the eyebrows and below and behind the left ear, have disappeared. The patient says that he feels well and strong to-day, while yesterday he was feeling weak and could hardly stand. He reports that yesterday he continued to sweat profusely, after which he was free from fever. The patient was given by mouth one tablet stovarsol dissolved in water. Urine was found normal. Leucocyte and differential counts were made by Ramirez (postea).

November 20, 1931, 2.30 p. m.—Temperature by mouth 37.2° C. The upper eyelid is now much less swollen, showing a faded brownish purplish color. The induration is greatly reduced and the eye can now be opened wider than before. The glands on the neck have all greatly subsided. The patient is feeling well. One and one-half tablets of stovarsol were administered to the patient.

November 21, 1931, 11 a. m.—Temperature 37.4° C. Brownish purplish discoloration still persists on the left upper eyelid, though the induration has greatly regressed and the patient can open the affected eye wider than yesterday. The glands continue subsiding, though the superior cervical glands still show slight bulging of the neck. One and one-half tablets of stovarsol administered.

November 23, 1931, 2.45 p. m.—Temperature 37.2° C. Brownish purplish discoloration still persists, under the left eyebrow the induration is greatly reduced. The swelling of the glands is reduced, the superior cervical glands no longer bulging out. The anterior auricular gland is still palpable, this region being elevated as compared with the right side. One and one-half tablets of stovarsol administered.

November 24, 1931, 2.30 p. m.—Temperature 37.2° C. No appreciable change from yesterday is detectable, save perhaps that the left eye is somewhat more opened than before. Two tablets of stovarsol administered.

November 25, 1931, 2.45 p. m.—Temperature 37.5° C. Only a slight induration is detectable under the left eyebrow, the left upper eyelid is still reddish brown. Glands still palpable on the affected side of the neck. The left anterior auricular gland has softened somewhat, but this region is still elevated. The same may be said of the superior cervical glands on the left side. Two tablets of stovarsol administered.

November 27, 1931, 2.45 p. m.—Temperature 37.5 ° C. Practically no change in the local symptoms is noticeable except that the left anterior auricular and the posterior cervical gland have further regressed. Two tablets of stovarsol administered.

November 28, 1931, 11.30 a. m.—Temperature 37.4° C. No change from yesterday. Two and one-fourth tablets of stovarsol administered.

December 1, 1931, 3.50 p. m.—Temperature 37.5° C. The discoloration of the left upper eyelid has further regressed, though it is still noticeable at a distance. The left eye is still smaller than the right eye. The glands have regressed in size, the left anterior auricular being quite soft now. No medicine was administered this day.

December 4, 1931, 1.55 p. m.—Temperature 37.5° C. The discoloration of the upper eyelid considerably regressed, but it is still noticeable at a

distance. The left eye is now only slightly smaller than the right eye. The glands smaller, particularly the left anterior auricular lymph nodes are smaller. No medicine was administered to-day.

December 8, 1931, 1.45 p. m.—Temperature 37.6° C. The left anterior auricular gland is larger now than it was yesterday, otherwise no change from yesterday. Two tablets of stovarsol administered.

December 9, 1931, 1.35 p. m.—Temperature 37.7° C. Same as yesterday. Patient dismissed.

SUMMARY

One case of human rat-bite fever of about two months duration was treated with stovarsol.

CONCLUSION

Stovarsol and allied preparations may be effective drugs in the treatment of human rat-bite fever.

A HUMAN CASE OF RAT-BITE FEVER TREATED WITH STIBOSAN

Stibosan having been found effective among the drugs that were tested on animals, it was desired to treat a human case of rat-bite fever with this drug in order to find out its possibilities in the chemotherapy of human rat-bite fever.

HISTORY AND COURSE OF THE DISEASE

October 27, 1931, 2.40 p. m.—Simeon Rasonable, 22 years old, male, while sleeping at 69 Padre Rada, Tondo, was bitten on the dorsal side of the left hand at the root of the middle finger, about 3 a. m. two weeks ago. An area surrounding the site of the bite, about 1 inch in diameter, presents an indurated red swelling, which according to the patient developed two days ago. There are three small scars visible on this area at the insertion of the middle finger, just below the knuckle. Lymphatic glands at the elbow are swollen, tender, and painful. Temperature by mouth 37.4°C.

Wassermann and Kahn tests were negative. The patient was given an intramuscular injection of 0.2 g of stibosan into the left buttock.

October 28, 1931, 3 p. m.—Temperature 37.6° C. The patient states that the pain in the hand, elbow, and axilla has diminished. He slept well last night. He also reports that he felt very weak after the injection of stibosan.

The redness on the hand extends up to the wrist now and down the little finger, involving about two-thirds of the proximal portion of the said finger. The swelling consists of a firm indurated œdema.

Smears were prepared from aspirated gland juice from one of the enlarge elbow glands. No spirochæte found.

October 30, 1931, 3.30 p. m.—Temperature 38.2° C. The redness and swelling are greatly reduced, and the induration has greatly diminished. The redness is limited to the upper third of the middle finger and to the corresponding knuckle. Above this the skin is of a dusky purplish color.

Patient reports that he had fever ever since October 28, 1931, and that he could not sleep last night. The pain in the cubital and axillary region persists. The patient was given an intramuscular injection of 0.2 g of stibosan.

October 31, 1931, 10 a. m.—Temperature 37.8° C. The patient reports that he was able to sleep well last night but that the hand was painful, the pain persisting even now. The epitrochlear and axillary glands are tender. The area of redness has subsided, though the swelling (œdema) has increased. The induration has further diminished. A dusky purplish discoloration of the skin over and around the site of bite still persists. The patient was given an intramuscular injection of 0.2 g of stibosan. A few moments after the injection, the patient vomited.

November 2, 1931, 3 p. m.—Temperature 38.2° C. The œdema is greatly reduced, being confined to the upper fourth of the middle finger and to the corresponding knuckle. The lymphatic glands are reduced in size and are much less tender. The patient reports that he sleeps well these days. An intramuscular injection of 0.2 g of stibosan was given. Five minutes after the injection, the patient asked to be allowed to go home because he felt very sleepy.

November 3, 1931, 2.30 p. m.—Temperature 37.6° C. The œdema has further subsided, and the redness has disappeared. The area of the bite shows a brownish dark discoloration contrasting markedly with the clear brown color of the normal hand. Tenderness of the glands has disappeared, and they are reduced in size. The patient reports that he feels well.

November 4, 1931, 2.30 p. m.—Temperature 37.0° C. The portion of the epidermis at the site of bite about 2 cm long by 1.5 cm wide is desquamating covered with slightly pinkish new skin. The œdema is further reduced as well as the discoloration. The glands are still palpable but not tender. Slight induration still present at the site of the bite. The sites of the injections of stibosan are indurated and tender. The patient states that he feels well. Intramuscular injection of stibosan was administered.

November 5, 1931, 3.20 p. m.—Temperature 37.3° C. The œdema has further diminished, and the desquamation continues. The patient reports that he did not feel sleepy yesterday after the injection and that he did not vomit. Wassermann negative; Kahn ±.

November 6, 1931.—Temperature 37.0° C. No œdema is detectable. The dark brown discoloration (pigmentation) persists. Desquamation has not progressed. Induration still appreciable. The glands at the elbow and axilla are greatly reduced in size, and they are no longer tender.

November 9, 1931, 3 p. m.—Temperature 37.0° C. Desquamation has advanced around the site of bite. Pigmentation as well as induration still persists.

November 11, 1931, 3.20 p. m.—Temperature 37.2° C. No appreciable change in local symptoms.

November 16, 1931, 3.30 p. m.—Temperature 37.3° C. No appreciable change except some more desquamation is noticeable. Pigmentation and induration still present. Glands greatly reduced, not tender. The patient was dismissed as cured and requested to report every Monday, or earlier in case he should develop headache or fever.

November 20, 1931, 3.30 p. m.—Temperature 37.7° C. The patient reports that he had fever November 18, 1931, from 9 p. m. to 3 a. m. the next morning and November 19, 1931, during the same hours. This morning when he woke up he felt pain in the lower internal part of the left thigh and could not stand up for about half an hour. A small painful and indurated efflorescence about the size of a small pea is palpable in this region. The patient was given an intramuscular injection of 0.2 g of stibosan.

November 21, 1931, 11 a. m.—Temperature 37.0° C. The patient reports that he was greatly alarmed yesterday because of an urticarial rash, which suddenly cropped up over his whole body. He shows indurated flat papules, not disappearing on pressure, on the left forearm (extensor surface); on the right leg (internal surface). The patient states that yesterday he felt pain in the right thigh. The pain in the left thigh still persists.

November 23, 1931, 3.30 p. m.—Temperature 37.2° C. The papules on the left forearm and the right leg still persist. They are indurated and red. Those on the left forearm are small, measuring from 0.5 to 3 mm in diameter. Those on the leg are rather large, about 2 cm in diameter on the surface of the skin, surrounded by deep induration. The tenderness is still present on the lower internal portion of the left thigh. There is also tenderness of the epitrochlear lymphatic glands. Tissue scrappings from one papule on the forearm and from one on the leg were prepared, to be examined for spirochætes. The tissue scrappings from the leg shows typical spirochætes in smears stained by Giemsa's method. The patient looks pale and sick and is rather weak. Wassermann ±; Kahn negative.

November 24, 1931, 3 p. m.—Temperature 37.1° C. The papules still persist but are slightly less indurated, being now less elevated than before. Two large lymphatic glands above the elbow are palpable; one is tender. Tenderness in the lower internal part of the thigh persists.

November 25, 1931, 3 p. m.—Temperature 37.4° C. Some of the papules that were present on the left forearm have disappeared, while others have flattened out. The papules on the right leg are without change; they are painful and tender.

November 27, 1931, 2.15 p. m.—Temperature 37.1° C. The papules have further flattened and have acquired a dusky purplish discoloration. The lymphatic glands above the left elbow are greatly reduced in size and are no longer tender. One tablet of stovarsol dissolved in water was administered to the patient by mouth.

November 28, 1931, 10.30 a. m.—Temperature 36.7° C. The lymphatic glands above the left elbow are soft and smaller. The lesions on the right leg have softened greatly and their purplish discoloration has almost disappeared. The papules on the left forearm have faded away, only three small ones are still to be discerned by their purplish discoloration.

December 1, 1931, 3.30 p. m.—Temperature 37.0° C. Small brownish macules are still to be seen at the sites of the former papules on the left forearm. One of the large papules on the leg has disappeared, and only a slight induration marks its site. The other one has softened and the skin over it is darkly pigmented. The lymphatic glands above the left elbow are reduced in size and are now the size of small beans. The patient

states that he feels well. Pigmentation at the site of the bite is very slight, and only a very slight induration is detectable.

December 2, 1931, 3.20 p. m.—Temperature 36.5° C. The macules on the left forearm are fading away, being smaller and not so conspicuous as yesterday. The induration on the right leg is further reduced in size and hardness, and the skin over it is desquamating. No change observed in the left epitrochlear glands.

December 3, 1931, 3 p. m.—Temperature 36.9° C. The macules on the left forearm have faded, and the glands above the left elbow are smaller and softer than they were at the last inspection. The induration on the right leg is reduced to a pigmentation; desquamation persists. The patient believes himself cured and wishes to discontinue treatment.

December 4, 1931, 3 p. m.—Temperature 37.0° C. Several macules on the left forearm have disappeared, and those remaining have so faded and are so reduced in size as to be almost invisible. The induration on the right leg and the lymphatic glands above the left elbow show no change. The patient reports that he had diarrhœa last night. One tablet of stovarsol given by mouth.

December 5, 1931, 11.30 a. m.—Temperature 37.1° C. The macules on the left forearm have further faded. Induration on the right leg has diminished.

December 7, 1931.—Temperature 37.1° C. One tablet of stovarsol administered.

December 8, 1931, 2.15 p. m.—Temperature 36.9° C. The pigmented macules on the left forearm are hardly visible now. Only a slight induration remains on the right leg, the desquamation at that site having further regressed. One tablet of stovarsol given by mouth.

December 9, 1931, 3.30 p. m.—Temperature 37.1° C. The pigmented macules are no more to be seen. Induration on the right leg and the desquamation have ceased. Patient dismissed.

SUMMARY

A case is reported of rat-bite fever in a patient who has been treated with stibosan. The beneficial effect of this drug on the course of the disease is clearly evident. The patient, apparently cured, developed a relapse at the place of primary lesion. At the same time, subsequent specific lesions developed at the places remote from that of the primary lesion. The treatment was resumed and terminated successfully by administration of stovarsol.

CONCLUSION

Stibosan was found to be a useful drug in the treatment of a human case of rat-bite fever. It may be particularly useful in cases in which vigorous arsenical treatment is contraindicated or as an adjunct treatment in combination with arsenicals.

THE BLOOD PICTURE IN EXPERIMENTAL RAT-BITE FEVER IN PHILIPPINE MONKEYS

TECHNIC

All the blood samples were taken at about the same hour of the day, early in the morning before feeding the animals.

One of the fingers of an upper extremity, preferably the thumb, was cleansed with alcohol and allowed to dry, then a deep puncture was made with a needle. The first drop of blood was discarded, subsequent ones being used for the blood pipettes and the smears.

For the total count an ordinary hæmocytometer white-cell pipette was used. Having a fairly large drop of blood, the tip of the pipette was applied to it and the blood carefully drawn up to the 0.5 mark. Then the diluting fluid (1 per cent solution of acetic acid) was drawn up to the mark 11. After mixing thoroughly by shaking, the fluid below the bulb was expelled and a fairly large drop was deposited in the edge under the cover slip of the Neubauer double-ruling counting chamber. Two counts were made each time and the average recorded.

For the differential count two absolutely clean and grease-free slides were used. A small drop of blood was taken on the slide on which the smear was to be made, at about 0.5 inch from one end; one of the edges of the "spreader-slide" was placed on the drop, and as soon as the blood ran along the edge, the spreader was drawn along with an even sweep to the other end of the slide, and a thin smear was obtained. After being thoroughly dried this was stained with Wright's stain.

In making the differential count we classified the cells in every other row across the slide, the edges always being included, and from 300 to 500 cells were counted each time.

The cells were differentiated according to the Schilling Torgau's classification, as follows:

- Basophiles.
- Eosinophiles.
- Neutrophiles.
    - Myelocytes.
    - Metamyelocytes.
    - Staff nucleated.
    - Segment nucleated.
- Lymphocytes.
- Large mononuclears.

After taking the blood samples, the temperature was obtained in the anus with a clinical thermometer, and the appearance of the lesions and other symptoms were noted.

In the human case (R. Laird) R–B (E. L.) samples were taken usually in the afternoon. The temperature was taken by mouth. The blood samples were taken from the patient's fingers, the technic being the same as that used in the case of monkeys.

DISCUSSION OF HÆMATOLOGIC FINDINGS

The total leucocyte count, in the course of artificial rat-bite fever infection in Philippine monkeys, varies considerably from day to day. When the daily counts were plotted in a curve, certain regularities in the behavior of the leucocytes became evident as well as the relation between the reaction on the part of the leucocytes and the other clinical phenomena concomitant to the course of the infection became known. From the attached charts (Plates 4 to 10) it is evident that the rise and the drop in the total leucocyte count is parallel to the rise and drop in the temperature curve. While in the early part of the curve the shifting of the leucocytes is synchronic, in the later part the excursions of the leucocyte curve appear slightly behind those of the temperature curve. Repeated attacks as they occur in the course of experimental rat-bite infection and which are discernible in the periodic elevations of temperature and, as mentioned before, in the periodic exacerbations of the skin lesions that go hand in hand with the invasion by the parasites of the blood stream are clearly evident in the leucocyte-count curve. Thus, the typical attack in rat-bite fever is characterized, as far as the blood picture is concerned, by leucocytosis. The differential count that is plotted on the lower part of the charts gives further information as to the kind of leucocytes involved in the periodic shifting of the blood picture. It can be seen that each individual attack is expressed by an increase of polymorphonuclears and simultaneous drop in lymphocytes. Of the other leucocytes, the staff-nucleated cells are somewhat increased coincidently with the rise of polymorphonuclears and there is a steady upward increase of the staff cells in the course of experimental rat-bite fever. The mononuclears, on the other hand, follow a curve parallel to the lymphocytes. The rest of the leucocytes show only insignificant changes.

Towards the end of a fatal experimental rat-bite fever infection, there is a considerable increase in total leucocytes, staff cells, and, at times, lymphocytes and mononuclears. Immediately before exitus and when the temperature plunges downward, all the leucocytes may show a downward drop. The clear indication of individual attacks as reflected in the blood picture—that is, a wide separation of the polymorphonuclear and lymphocyte curves—is best evident in the charts for R–B–10 and R–B–14 (Plates 7 and 9).

THE EFFECT OF SPECIFIC TREATMENT ON THE BLOOD PICTURE IN RAT-BITE FEVER

The effect of specific treatment on the blood picture in rat-bite fever is best evident in monkeys R–B–8 and R–B–9 (Plates 5 and 6). The animals had been inoculated with a Manila strain of *Spirochæta morsus muris*, and the disease was allowed to run its course for seventy days. Typical initial lesions and a characteristic temperature curve, as well as leucocytosis, were observed in the course of the first seventy days. Several distinct attacks, as indicated by the elevation of the temperature curve and the leucocyte reaction, were observed in the course of this period of time. Seventy days after inoculation, 0.015 gram of neosalvarsan was injected intramuscularly to both of these animals. In one case a striking increase of leucocytes was noticed, after which the leucocyte curves show a tendency to return to normal. The excursions of the curves are more moderate and the periods of the separation of the polymorphonuclear and the lymphocyte curves are shorter than before. The staff cells that had risen perceptibly during the first seventy days of infection returned practically to normal following the one injection of neosalvarsan. The ninety-ninth day of the infection, 0.04 gram of stibosan was injected to both animals, intramuscularly. The leucocyte curve following this injection shows a further tendency to return to normal until the terminal rise of the total leucocyte count set in, which was due to an increase of polymorphonuclears.

THE EFFECT OF REINFECTION WITH RAT-BITE FEVER ON THE BLOOD PICTURE IN AN INFECTED AND TREATED PHILIPPINE MONKEY

One of the two monkeys that had been infected with rat-bite fever and treated was subsequently reinoculated intradermally with the same strain of *Spirochæta morsus muris* one hundred twenty-one days after the original inoculation. Within the brief time that the animal survived, following the

reinfection, the blood picture again showed the same leucocyte reaction as was observed on the same animal when first inoculated. The terminal leucocyte reaction was of the same type as observed in untreated single-inoculated Philippine monkeys.

CONCLUSION

A characteristic leucocytic reaction accompanies an attack of rat-bite fever. The reaction consists of leucocytosis, due mainly to an increase of polymorphonuclears but also to the increase of staff-nucleated leucocytes and concomitant lymphocytopenia.

The leucocytic reaction is synchronic with the elevations of temperature. This shifting of leucocytes disappears some time after treatment, but reappears upon reinfection following treatment.

HÆMATOLOGIC OBSERVATION ON A HUMAN CASE OF RAT-BITE FEVER

In order to illustrate the similarity between the blood picture in human rat-bite fever and that encountered in experimental inoculated Philippine monkeys, the temperature chart of a human case is included (Plate 4). The details of this human case are recorded on page 13. The curve given in this chart was constructed from individual counts made at frequent intervals, and the similarity of the curves registering the total count, as well as the differential counts, with those of the infected monkeys is at once evident. The next day after the first count was made the treatment began. Following the first treatment the temperature rose and, coincidently, a rise in leucocytosis is apparent; the latter is due to increased polymorphonuclears with concomitant drop in lymphocytes. In the course of the treatment, the separation of the curve registering the polymorphonuclears from that registering the lymphocytes is clearly apparent, the individual attacks being clearly discernible, while the temperature curve remains throughout the treatment, with slight variations, at 37.5° C. Thus, the leucocyte curve in man, as in the case of monkeys, is a better indication of the continuance of the disease than the temperature curve. The only difference between the blood findings in monkeys and in man appears to concern the eosinophiles; that is, a considerable increase in this form of leucocytes in man throughout the infection and treatment, while in monkeys the eosinophiles

varied very slightly and insufficiently to serve as a signal of the infection.

That the blood picture, as just discussed, is characteristic of rat-bite fever in general is evident from the fact that it was found in monkeys as well as in man and that our findings in the Philippines agree with those made elsewhere. So, for instance, Kuipers and Ruys[7] made identical findings in a human case of rat-bite fever in Holland. They summarized their findings as follows: Leucocytosis with relative lymphopenia and an eosinophilia was found during the attacks. The number of eosinophiles rose markedly a few days before the attacks. Eosinophilia occurred during convalescence.

Ishizu Yoshitada injected the blood of rat-bite fever into guinea pigs and found a distinct leucocytosis with relative and absolute diminution in the number of lymphocytes and a more or less distinct increase in the pseudoeosinophiles and monocytes.

Our blood findings in experimental human rat-bite fever indicate that in an obscure case of human rat-bite fever hæmatologic examinations may aid in establishing the diagnosis. It may further serve as a directive of treatment.

EXPERIMENTS CONCERNING IMMUNITY

In the following experiments we have endeavored to obtain as much information regarding immunity in rat-bite fever as is possible to secure by animal experimentation. By varying certain factors and leaving others unchanged we have studied the effect of particular factors upon the course of the infection in experimental animals. It has been found in series of experiments that by observing certain precautions, as to the mode of inoculation and as to the quantity of inoculum, certain manifestations of rat-bite fever occur in experimental animals with a constant regularity. It was hoped that by variations of the factors some modification of the course of the infection might become apparent that would enable us to recognize them as signs of beginning or partial immunity. The initial lesions, the fever, the change in body weight, and the occurrence of the spirochætes in the blood stream were constant signs of successful infection in experimental animals. The experiments were

[7] Kuipers, F. C., and A. Charlotte Ruys, Een geval van ratterbeetz-siekte [A case of rat-bite fever], Nederl. Tijdschr. v. Geneesk. 72d year, 1st half, No. 10 (March 9, 1929) 1207–1220. (With 2 charts and 4 figures on 1 plate; 18 references.)

arranged so that the dependency on the experimentally controllable factors of the degree of the symptoms and of the time at which the symptoms set in after inoculation might become apparent.

THE RELATION BETWEEN THE AMOUNT OF INOCULUM AND THE COURSE OF THE INFECTION

This experiment was arranged, primarily, for the purpose of finding indications in the appearance of the symptoms of the experimental rat-bite infection that might allow us to draw conclusions as to the progress of multiplication of the parasites in the host's body following inoculation. The experiment was arranged in the following way: Three guinea pigs of equal body weight were inoculated at the same time with decreasing amounts of the same inoculum. Blood of an infected guinea pig in which the spirochætes were present was used for that purpose. The three inoculated guinea pigs were examined daily with the view to establish the onset, extent, and duration of the following symptoms: The local lesion, the fever, and the presence of spirochætes in the circulating blood. It was found that in the first guinea pig, which received the largest amount of spirochætes, the local lesion developed early. It exhibited considerable inflammatory reaction besides induration. The second guinea pig, which received subcutaneously a smaller amount than the first one, developed local lesion without noticeable inflammation and somewhat later than the first one. In the third guinea pig, inoculated with the smallest amount of spirochætes, no perceptible local lesion developed.

The fever curve in the first two guinea pigs under discussion shows a moderate but typical rise. In the third guinea pig the elevation of the curve is smaller than in either of its mates. The onset and the duration of the fever in each of the three guinea pigs were the same, though they varied in degree. All three animals included in these experiments revealed the presence of spirochætes in the blood. The time necessary for the appearance of the spirochætes in sufficient numbers to be detected by the dark-field microscope in the circulating blood stood in inverse proportion to the quantity of the inoculum. That is to say, they were found first in the blood of the guinea pig that received the largest amount of spirochætes; later, they were found in the second animal that received a lesser dose than the first one; and in the third guinea pig, which received the small-

est amount of inoculum, the parasites appeared in the blood later than in the blood of either of its two mates.

One of the manifestations of rat-bite fever in experimental animals is loss of body weight. In this particular experiment, the three guinea pigs involved were of equal weight; that is, 350 grams each. In the course of the first month of infection, the two guinea pigs that manifested distinct initial local lesion and a distinct fever suffered a loss of body weight (80 grams). The third guinea pig, which received 0.001 cubic centimeter of the inoculum manifested no initial lesion and a slight elevation of temperature, gained 20 grams in the course of the first month of infection. The drop in body weight in the first two guinea pigs was particularly conspicuous after the fever subsided. During the same time the third guinea pig, which received the smallest amount of inoculum, registered increase in body weight. This change in body weight could not be attributed to any other factor for the animals were kept under the same conditions and no other change occurred, such as incidental infection, pregnancy, etc.

It is, therefore, evident that in normal susceptible animals the course of the disease and its manifestations, as well as the ultimate outcome, depend on the amount of parasites originally inoculated. The severity of the symptoms of experimental rat-bite fever, such as the initial lesion, the degree of fever, and the incubation of the septicæmic stage of the disease, stands in inverse proportion to the quantity of the parasites inoculated, equal virulence granted.

COMPARATIVE STUDY CONCERNING THE OCCURRENCE OF SPIROCHÆTA MORSUS MURIS AS TO TIME AND NUMBER OF PARASITES IN THE PRIMARY LESION AND IN BLOOD OF EXPERIMENTAL ANIMALS (GUINEA PIGS) INOCULATED WITH RAT-BITE FEVER.

This experiment was arranged in such a way that six guinea pigs were inoculated with a Manila strain of *Spirochæta morsus muris* by intradermal injection of a diluted blood of infected guinea pigs, which contained the parasites in sufficient numbers to be found with a dark-field microscope. The object was to follow the pathogenetic progress of the infection from the beginning to the end of the infection which invariably, with Manila strains, ended fatally.

PROCEDURE

After the inoculation the temperature of these animals was taken by rectum and inspection was made every day, spirochætes were looked for in the blood taken from the foot pad and from the local lesion. The material from the local lesion was taken as follows: The local lesion was held firmly between two fingers of the left hand and the center or the periphery of the local lesion was punctured, parallel to the surface of the skin with a sharp needle. After this, gentle pressure was applied with the fingers, fixing the local lesion until a serous fluid oozed out. This fluid was examined for the presence of spirochætes under dark-field illumination and by staining.

CONCLUSIONS

The results of this experiment show that the spirochætes are detectable in the local lesion on the first day of its development. In the blood they were demonstrable two to thirteen days (an average of seven days) later than in the local lesion, and in the majority of cases the spirochætes in the local lesion were more numerous at that early time than in the blood at any time during the infection. Furthermore, the demonstration of the spirochætes is easier in the primary lesion than in the blood, because of scarcity of the red cells in a slide made from the initial lesion.

The periphery of the local lesion showed more-numerous spirochætes than the center of the lesion.

This experiment demonstrates that the spirochætes (*Spirochæta morsus muris*) increase first at the point of inoculation and spread therefrom to the periphery. Later they invade the blood.

IMMUNITY IN EXPERIMENTAL RAT-BITE FEVER

Having become familiar with the clinical course and manifestations of rat-bite fever in various experimental animals, as produced by the Manila strains, we have arranged a series of experiments to study the effect that an infection by *Spirochæta morsus muris,* in experimental animals, may have on the clinical course and manifestations of subsequent inoculations. This was done in two ways: First, by superinfection; that is, by inoculation performed on animals already inoculated and in which the parasites were still demonstrable. The second procedure was

to study the effect of the preceding infection that has been terminated by specific treatment on the course of subsequent infection by the same strain of spirochætes as were used for the first inoculation.

SUPERINFECTION

Guinea pigs successfully inoculated with rat-bite fever were superinfected by intradermal inoculation at various intervals of time. The development of the local lesion at the point of superinfection was observed as to its incubation period, extent, clinical character, and the number of spirochætes it contained. The effect of the superinfection on the existing lesions that were produced by the first inoculation was studied and the effect of the superinfection on the fever curve, on the parasites in the blood stream, as well as on the mortality was noted. It has been observed throughout these experiments that superinfection with rat-bite fever produced at times a distinct effect on all the manifestations of the first infection, that have been just mentioned; that is, the superinfection produced a change in incubation of the local lesion, distinct rise of the temperature curve, a vigorous local lesion, at times an exacerbation of pre-existing skin lesions, and more rapid death than in single inoculated animals. Although not all of these manifestations occurred always and in every experimental animal, yet the compiled findings of these experiments indicate that superinfection performed in the early acute stage of experimental rat-bite fever has a distinct and definite effect on the existing infection in the negative direction. The superinfection produces what may be termed a negative phase, and rat-bite fever being an infection with high mortality it ends inevitably in the early death of the animals concerned.

The results of experiments concerning superinfection with *Spirochæta morsus muris* showed that the course of the disease in superinfected animals was more rapid than that in single-inoculated animals of the same kind. While the average duration of the disease in single-inoculated animals was 56 days, the shortest being 11 and the longest 130 days, the course of the disease in superinfected animals lasted on the average 45 days, the shortest being 33 and the longest 56 days. Another effect of the superinfection was noticeable in the number of parasites encountered in the circulating blood and in the time of their appearance in the blood. While in singly inoculated animals, fol-

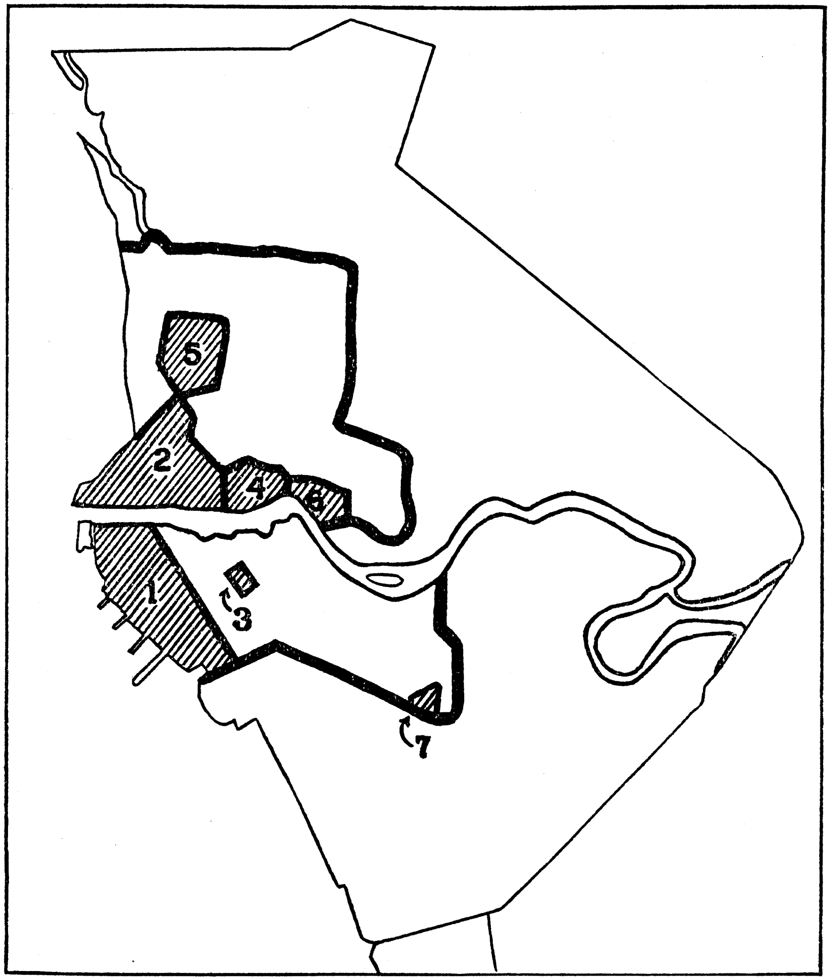


FIG. 1. Outline of the City of Manila, indicating danger zone and foci of greatest danger with regard to rat-bite fever and plague.

lowing the onset of fever, the parasites occur in the blood somewhat behind the beginning of the development of local lesion in the superinfected animals, the parasites were found in the blood at times as early as two weeks after superinfection. As to the number of parasites appearing in the blood, following the superinfection, in twelve of twenty-four animals enormous numbers of spirochætes were found in the circulating blood when superinfection was performed within seven weeks after the original inoculation.

REINFECTION

The rat-bite fever infection, in the experimental animals used, with the exception of mice, ended lethally. Following superinfection the death occurred much quicker than it did in single-inoculated animals of the same kind.

The possibility of investigating the conditions of immunity, as they may exist in rat-bite fever, by superinfection is therefore greatly limited by the early death of the animals and, beyond the negative phase, the subsequent stages of immunity could not be well ascertained by this procedure with the Manila strains. Therefore, it was decided to adopt another procedure for the study of the positive phase of the immunity in rat-bite fever; that is, of the partial or complete resistance to inoculation. The procedure of reinoculation that has brought satisfactory results on other occasions was adopted for the study of immunity in experimental rat-bite fever. By reinfection we understand inoculation performed repeatedly, each individual infection being terminated by specific treatment before the death of the animal, due to the infection, occurs. We have, therefore, inoculated successively a series of animals. As long as the animals did well in the course of the infection, the disease was allowed to run its course as long as possible without jeopardizing the life of the animals. When the general symptoms occurred—such as, loss of weight, loss of appetite, and general weakness—the animal was treated. It naturally happened, at times, that the infection was unintentionally allowed beyond the point at which the life of the animal could be saved. When the second and each subsequent reinfection was made, normal control animals were inoculated simultaneously with the same amount of the same inoculum to prove the viability of the material used as inoculum for the test of resistance.

By the process of reinfection it was found that certain clinical signs of experimental rat-bite fever failed to appear after the procedure of repeated inoculations and treatments has been continued for some time. The gradual disappearance of clinical symptoms in reinoculated animals followed a certain sequence. In this experiment it has been ascertained that the immune animals received a sufficient amount of the inoculum to cause normal control animals of the same species to develop the full clinical picture of the experimental rat-bite fever. The procedure of repeated inoculations has failed to develop some or all clinical manifestations of the disease. The typical clinical

symptoms of experimental rat-bite fever could be followed, step by step, in the normal control animals. It was noticed that in those animals that had been subjected to repeated reinoculations, the degree of the symptoms was considerably less than observed in normal control animals inoculated at the same time and with the same amount of the same inoculum. Thus, the incubation period, due to partially developed immunity, was changed; sometimes shortened, mostly prolonged. The initial lesion was far smaller and healed quicker than in normal animals. The fever was of less degree and the examination of blood revealed very few spirochætes in the circulating blood. In highly immune animals, the local lesion did not develop at all. The temperature curve of these animals showed no increase in intensity, running after repeated inoculations the same course and degree as before, and the spirochætes could not be demonstrated in the circulating blood by microscope.

This is the degree of immunity, as is known in syphilis and yaws, where inoculation of animals that have had the disease for some time produces no local or generalized clinical manifestations. These findings of absence of lesion, absence of fever, absence of the parasites in the blood, and absence of acute death in experimental rat-bite fever can be considered as the highest degree of immunity that the infection itself may produce.

These findings, however, as in treponematoses, do not indicate that the parasites in the infected body have been destroyed. When immune animals were sacrificed and the internal organs, such as the spleen and lymph glands, were inoculated into normal susceptible animals a typical rat-bite infection developed, proving that the tissues in question still harbored virulent *Spirochæta morsus muris*, even though in such small numbers that they could not be discovered by thorough microscopic examination.

In some of our animals the procedure of reinfection was continued for a considerable number of months, yet the findings in these animals were the same as in those that showed absence of clinical symptoms in the early stage of the experiment; that is, absence of parasites in the circulating blood as demonstrated by microscope. This indicates that a condition similar to that in syphilis and yaws exists in rat-bite fever. Once the body tissues of the experimental animals reached the stage of tissue nonreactivity, the immunity could not be forced higher by further reinfections performed in the stage of tissue nonreactivity.

CONCLUSIONS

The immunity in experimental rat-bite fever is analogous to that in treponematoses. It manifests itself by the absence of certain symptoms, as follows:

1. Change of the incubation period.
2. Change in degree or character of the local lesion that develops at the place of intradermal inoculation.
3. Absence of subsequent lesions surrounding the primary lesion.
4. Change in the degree of fever from a slight decrease to an absence of fever.
5. Total absence, even though temporary, of the parasites in the circulating blood.
6. Absence of acute death.

EXPERIMENTS CONCERNING INTRAUTERINE TRANSMISSION OF INFECTION AND IMMUNITY IN RAT-BITE FEVER

In its pathogenicity the disease known as rat-bite fever resembles treponematoses. The initial lesion, the subsequent skin lesions, the repeated relapses of lesions, and the positive serologic findings are manifestations that rat-bite fever has in common with syphilis and yaws. The question of intrauterine transmission of the infection is, therefore, of interest, in as much as the solution of this question, jointly with other experiments and observations, may lead to better understanding of the disease.

White mice were selected for these experiments for the reason that they exhibit a chronic infection and the mortality among them due to rat-bite fever is much lighter than among guinea pigs, rabbits, and monkeys. Monkeys, furthermore, rarely bear young in captivity.

Four litters of young white mice from three infected mothers were used. One of the mothers delivered young three days after the inoculation, the second one three weeks, and the third one five and ten weeks, respectively, after the inoculation. The two last-mentioned mothers presented in their blood demonstrable spirochætes at the time of delivery. Some of the young white mice were inoculated with rat-bite fever some time after birth, while the rest of them were not inoculated. The young were allowed to stay together, each litter with its mother. The blood of the young was examined every other day, before and after the inoculation for a period of thirty-one days; the blood of three of them, for a period of ninety-three days.

None of the young white mice, born of mothers infected with rat-bite fever, showed any evidence of either infection or immunity that might have been transmitted during intrauterine life. The relatively prolonged incubation period of the subsequent artificial inoculation among the young mice in question, as compared with that observed in normal controls, may tempt one to suspect that some degree of immunity may have been transmitted in utero, but the offspring of Ms–28 likewise showed prolonged incubation. It was born three days after the inoculation of its mother, hardly sufficient time for immunity to develop.

An additional experiment was performed with pregnant guinea pigs. Three guinea pigs in an advanced stage of pregnancy were inoculated with 0.03 cubic centimeter of guinea pig's blood containing numerous spirochætes. The inoculation was performed intradermally. The course of the infection was regular. However, all of the three pregnant guinea pigs miscarried. While in M–78 spirochætes were found in the blood of the mother two days before miscarriage, in M–79 spirochætes were not found until four days after miscarriage, and in M–80 they were found in unusually large numbers the day of miscarriage. In the first two guinea pigs, miscarriage preceded by two or three days the highest peak of the temperature curve, and in the third one the miscarriage was coincident with the finding of unusually large numbers of spirochætes in the blood. The fœtuses of M–79 were examined for spirochætes but none was found.

In this second experiment concerning intrauterine transmission of rat-bite fever, the evidence is again negative. It must be considered that in this experiment the infection was in its acute stage and set in already pregnant animals. The abortion was undoubtedly due to the high fever in these cases. In the experiment on mice, the infection was in its chronic, so to speak latent, stage when the pregnancy occurred. It terminated normally, fully developed living young mice having been born in due time. This difference in the arrangement of the two experiments may account for the difference in the course of the pregnancy.

In the available literature we found a report that bears on this question by Salimbeni, Kermorgant, and Garcia. These authors [8] claim that guinea pigs born of parents infected with

[8] C. R. Soc. Biol. No. 24 93 (1925) 337.

the spirochæte of rat-bite fever may become infected at birth. Our experiments with white mice supply no evidence of intrauterine transmission of either infection with rat-bite fever or immunity. Much might depend on the habit of the particular kind of animal, and the transmission of the disease appears to be more likely during the birth or shortly after than during the intrauterine life. (See transmission by contact.)

EXPERIMENTS CONCERNING TRANSMISSION OF RAT-BITE FEVER AMONG LABORATORY ANIMALS BY MEANS OF CONTACT AND BITE

DIRECT CONTACT

Two normal young guinea pigs were placed in the same cage with three other young guinea pigs. The latter-mentioned animals had received inoculation with rat-bite fever and in due time showed symptoms and manifestations of infection in the form of local lesions, fever, alopecia, loss of weight, and presence of spirochætes in the local lesion and blood. The two normal guinea pigs remained in direct contact with the three successfully infected ones for seventy-three days. Their temperature remained normal and spirochætes were not found in their blood. They showed neither skin lesion nor loss of weight during all this time. The five guinea pigs concerned in this experiment were young animals weighing 350 grams at the beginning of the experiment. Being young, they did not fight each other.

SUCCESSFUL TRANSMISSION OF RAT-BITE FEVER AMONG GUINEA PIGS BY BITE

A large male guinea pig, weighing 750 grams and infected with rat-bite fever, was placed in a cage with two normal male guinea pigs. In the fight that ensued, the large infected male guinea pig was observed repeatedly biting the normal guinea pigs. After due incubation, both of the bitten guinea pigs showed typical lesions, mostly on the back of the body at the places of bite. They both ultimately died, and spirochætes were found in the blood of one of them during life.

These two observations showed that transmission of rat-bite fever among animals (rodents) is not likely to take place by direct contact but that the disease is readily transmitted by bite. The animals concerned in this experiment harbored no bloodsucking insects.

THE DISTRIBUTION OF HUMAN CASES OF RAT-BITE FEVER IN MANILA (1931–1932) AS COMPARED WITH THE DISTRIBUTION OF HUMAN PLAGUE CASES IN THE SAME CITY IN 1912–1914.

INTRODUCTION

Having been the sole officer to examine personally, by laboratory methods, all of the suspected cases of bubonic plague among rats and humans during the last outbreak in Manila (1912–1914), the writer (Schöbl) projected more recently and carried out, with the aid of collaborators, investigations concerning rat-bite fever in the City of Manila, Philippine Islands. Tracing the human cases of rat-bite fever in Manila in 1931–1932, as to their distribution throughout the city districts, personal observations on bubonic plague of twenty years ago emerged from the writer's memory. A striking resemblance of the distribution picture of rat-bite fever in Manila with that of human plague, in the same city, became clearly apparent. The last outbreak of plague in Manila having been placed on record in all its details,[9] it was not difficult to draw a comparison of the two outbreaks, separated though they were by a span of twenty years, by the writer who remained continuously throughout that time in the same official capacity. The analysis and interpretation of the outbreaks with practical conclusions are presented in this communication.

In rat-bite fever we are dealing with an infectious disease of rats that shows a very low mortality and is transmitted from rat to rat and from rat to man directly. Clinical history of patients and experimental evidence support the claim that the disease is transmitted exclusively by a bite.[10] It is, therefore, a wound infection. The character of the wound and the clinical appearance of the primary lesion, which always develops at the site of the bite, are prima facie evidence of the occurrence; and the bite by a rat, being rather severe and painful, is an event which, in the daily life of any person, no matter how low his intelligence and acuteness of observation may be, cannot remain unnoticed by the patient himself or his relatives. The

[9] Jackson, T. W., Plague, etc., with bacteriological observations by Otto Schöbl. Press of J. B. Lippincott Company. Copyright, 1916; 192 pp., 10 illus.

[10] The possibility of rat-bite fever being transmitted by fleas is being investigated by Lieut. Surgeon S. Arima.

history given by the patient as to the place, time, and the donor of the infection is unerringly reliable. The clinical course and manifestations of the disease in man cannot be confused with any other known disease, and the demonstration of the causative agent by direct or indirect laboratory methods offers no great difficulty.

The epidemic as well as endemic of this disease is maintained continuously by rats. In man the disease, when properly treated, has no mortality. Human cases of rat-bite fever are sporadic, and the incidence is incomparably lower than that in plague.

Consequently, no radical and extensive control measures are necessary and the course of the epidemic as well as of the endemic among the rats, as indicated by the occurrence of human cases, may be allowed to run undisturbed by measures that are necessary for the control of an outbreak of bubonic plague. In other words, the condition prevalent in rat-bite fever is favorable for the study of outbreaks, epidemics, and endemics, of rat-borne human diseases in a particular community.

In bubonic plague, on the other hand, we are dealing with an infectious disease of rats (and other rodents) that shows a high mortality and is transmitted from rodent to rodent and from rodent to man indirectly by means of fleas, which may remain infectious for a considerable period of time after all infected rats in a given focus have been killed, either by rat-control measures or by death due to the disease itself. In addition to the variable factors in the spreading of rat-bite infection among rats, the variable factor of fleas enters into the spread and maintenance of plague infestation. In patients the place and the time when they acquired the disease cannot be ascertained from the history of the patient or from clinical findings. Thus, a search for plague-infected rats becomes necessary in places visited or occupied by the patient in the immediate past. This laborious and costly procedure of establishing the focus of plague infection in a community is rendered more difficult by the fact that due to the indirect transmission the plague epidemic among rats precedes that among humans; by the time the first case of human plague is found rats dead of plague may have been removed by street cleaners, by occupants of the premises, and by scavengers; therefore, no rats are found or, if found, they are beyond recognition as plague infected.

From this general discussion it should be clear that the study of the epidemiology of rat-bite fever in a port like Manila, which is constantly exposed to the introduction of bubonic plague from surrounding ports, the knowledge of rat-bite fever distribution should be of value as a guide for rat-control measures, provided that a close correlation exists in the epidemiology of these two rat-borne diseases. The importance of such study will be quite apparent with regard to Manila when it is considered that in the districts of the city that will be discussed later, and which from the standpoint of plague introduction represent the vulnerable spots of the city, no permanent improvement of the situation has been made in the last twenty years and no indication is seen that such improvement will be accomplished in the future. As in the past, the plague-control agencies will content themselves with emergency measures; that is, trapping and poisoning of rats and destruction of fleas in plague-infected districts when bubonic plague visits Manila, sooner or later, in the future. In the meantime, in the off season, rats are trapped as a preventive measure with the view of locating plague among rats; this has gone on at the rate of one hundred to two hundred rats a day for the last twenty years, to the intimate knowledge of the writer.

The distribution of the two rat-borne diseases in question may be presented by discussing the occurrence of human cases by districts. The introduction of the infection among rats may be well visualized if one acquaints the reader with the topography of the City of Manila where the shore life and the movements of the ship population and of the cargo take place. The common ship rat (*Mus norvegicus*) follows man. It is a city dweller and follows the transient human population. Spurred by the same motives as his human shipmate, when ashore, the ship rat visits and inhabits places where food is easily obtainable; the rat may have landed by going overboard or may have been landed with freight.

The wandering rats follow man on shipboard throughout all ports of the world. Ashore, in a port like Manila, they follow the routes of the ship's crew and the cargo. They are more likely to be left behind than their human shipmates and become permanent inhabitants of the port city where they deserted their ship.

The discussion regarding the distribution of the two diseases concerned necessitates a brief description of the City of Manila.

The City of Manila is located on Manila Bay and is divided into a northern and a southern section by Pasig River, which flows out of a lake located 25 kilometers south of Manila. The river within the City of Manila is spanned by three bridges designed for general traffic and one suspension bridge for pedestrians. The last of the four bridges, up the river, rests on a small island within the river, while the others are shore-to-shore bridges.

Throughout the city, but particularly in the section on the right river shore, are many canals, so-called "esteros," which communicate with each other and connect the bay with the river or the lower and the upper stream of the river. These canals serve as highways for transportation by means of which small row boats and lighters bring produce to the markets that are located on their banks. Some serve as highways for the distribution of ships' cargoes. This means of freight transportation is gradually giving way to motor-truck and other kinds of overland transportation. From the point of view of our discussion these canals represent a certain type of barrier and, like the river, determine, to some extent, the movements of the rat population; therefore, the spread of rat-borne diseases in Manila. Bridges, shallow places, and uncovered lighters make convenient crossings for rats.

Large ocean-going steamers come alongside the piers that are located in the southern section of the city; their lines are well protected by rat guards. Interisland steamers and craft of various sizes enter the river and tie up along either shore as far up the river as the bridges allow. Small barges and lighters go up the river beyond the first bridge and enter some of the canals. Consequently, from the epidemiologic standpoint the Manila water front includes, not only the bay shore but also the river front on both sides as far up stream as the first or perhaps the second bridge. The esteros represent extensions of the water front. Small craft tie up between larger vessels, touching each other or tieing to the sides of larger ships at times, so that rats can easily pass from ship to shore or from shore to ship.

The San Nicolas-Tondo district adjacent to the bay shore and to the northern river shore is easily the most-crowded section of the city with respect to human population. Quiapo and Santa

Cruz districts are about as thickly populated; however, the latter contain large empty squares and wide streets, which San Nicolas and Tondo districts lack. The largest number of storehouses ("go downs" or "bodegas,") are in San Nicolas and adjacent districts. The south shore of Pasig River, on the bay shore, is occupied by modern buildings, modern storehouses, and the Custom House, all located along the piers; while the storehouses in San Nicolas and Binondo districts are old buildings, mostly built in Spanish times. Separated from the piers area by wide playgrounds is the old Walled City, which represents from our point of discussion a city within a city. It has changed very little within the last two hundred years (see Plates 1 to 3). It is surrounded by playgrounds; that is, wide open spaces and parks where the old defensive moats used to be. The moats have been filled since the American occupation, planted with lawns, and gradually changed into playgrounds, parks, and the so-called "Botanical Gardens." Thus, this section of the city is bounded on three sides by playgrounds and parks—that is, wide open spaces—and on the northern side by the river. The old battlements, bastions, and fort walls are still preserved. No modern construction has taken place within the Walled City for many years. Immediately within the walls are large buildings occupied by Government offices, monasteries, colleges, and similar institutions—that is to say, buildings that are scarcely inhabited by a permanent population, and very few people remain in these buildings during the night. The heart of the Walled City is residential; the main blocks in the center contain restaurants and food-handlers' shops and represent the most-crowded section of the Walled City. They are the blocks surrounded by the four streets Anda, Cabildo, Potenciana, and Solana. There is no public market in this section of the town. One would hardly wish for a more-suitable spot than Intramuros in Manila to serve as a field for epidemiologic observations of this sort.

Foreign vessels arrive in Manila at the piers, which are located on the reclaimed land, the so-called "Port Area," on the bay shore in a southern direction from the mouth of the river. The buildings in this district are modern, as rat proof as possible, and offer little inducement for the immigrant rat to linger about. No case of human rat-bite fever was reported in 1931 from this area; which, though crowded with people during the daytime,

harbors little permanent population. Likewise, in 1912–1913 no human case of plague was found in this area. However, numerous dead rats were found and thrown into the bay by the guards of storehouses, and a cat kept in a storehouse as a rat-control measure was found sick and died of plague.

Adjacent to the Port Area and separated from it by a stretch of playgrounds, lies old Manila, Intramuros, the Walled City. As mentioned in the description of this district, the heart of the Walled City is the place where the ship's crew and the ship rat obtain food and refreshment. The four blocks of houses bounded by Cabildo, Potenciana, Solana, and Anda Streets, abound with small restaurants, refreshment places, bars, hotels, and ice-cream parlors. Real and Magallanes Streets intersect in these four blocks. Besides the food-handling establishments of various sizes, habitations both downstairs and upstairs are intermingled with crowded lodging places in these two-story houses.

Three human cases of rat-bite fever have been reported from these blocks. One contracted rat-bite fever in Anda Street, another in Solana Street, and the third in Cabildo Street.

The Walled City was visited by plague during the last two outbreaks in the City of Manila (1912–1914 and seven years previously). It was the only district of the city located south of the river where human plague has been contracted. The cases were few and easily traceable. During the 1912–1914 outbreaks, plague-infected rats were trapped in this locality; that is, in Cabildo and Anda Streets. The coincidence of rat-bite fever and plague, both in humans, is most remarkable in this district of the city due to its general unchangeable geographic condition.

Across the river and north of its mouth is San Nicolas district. The river front, from the lighthouse, which marks the mouth of the river, almost to the first bridge, is lined with all types of storehouses that harbor offices on the upper floors. Small restaurants, food-handlers' establishments, and bars line this river front within a few feet of the actual embankment.

From the river front this district spreads northerly into Tondo district and in the eastern direction into Binondo. San Nicolas district represents a triangle bounded by the river shore on one side; by a canal, Estero de Binondo, on the eastern side;

and by seashore and Azcarraga, a wide street, on the western side. The point of the triangle on Azcarraga reaches Tutuban Station, the main terminal of the Manila Railroad Company. On the eastern side of the Estero de Binondo lies Binondo district. It is bounded by the river shore, on the southern side by the Estero de la Reina, on the eastern by Azcarraga Street. The north side of Binondo is less inhabited than the southern. The greatest population is along Dasmariñas Street as far as the Binondo church and southerly as far as the Escolta, the main business street of Manila. To the north from these two districts of San Nicolas and Binondo lies Tondo district and the heart of it is Tutuban Station. These three districts might as well be considered as one from the viewpoint of epidemiology of rat-borne diseases. On two fronts they are bounded by water; namely, the bay and the river.

Four cases of human rat-bite fever were registered in these three districts, in places rather widely separated from each other.

During the last outbreak of plague 1912–1914 the greatest number of human-plague cases came from these districts. Also the largest number of plague rats was found there. Due to the crowded population and to the uninterrupted continuity of houses, it was at times difficult to group the cases of plague into definite foci. One point stands out, however, as significant. That is, the railroad storehouses at Tutuban Station, where fifteen cases of human plague among laborers were found within a few days. Here again the agreement between the distribution of rat-bite fever and plague is apparent. A case of rat-bite fever was contracted by a person living in Dagupan Street, which is the street facing the whole length of the railroad station on the western side.

Quiapo district, a comparatively small section, and the southern part of Santa Cruz, which is the district lying between Quiapo and Binondo, can be considered from an epidemiological standpoint as one. They are bounded westerly by the Estero de la Reina, southerly by the river front, easterly by the Estero de San Miguel, and towards the north the line is formed by the wide street Azcarraga, which runs in front of Bilibid Prison. This is the heart of commercial Manila. Two bridges for general traffic and one bridge for pedestrians connect the two shores of Pasig River within these epidemiologic districts. A large

market located on the riverside in Quiapo is known as the "Quinta Market." The streets leading from this market, Villalobos and Ocampo particularly, were (in 1912–1914) foci of human and rat plague. One case of rat-bite fever was noted in this neighborhood.

The last district in which rat-bite fever was found is Paco. It lies on the southern shore of Pasig River and is outlined on the northern part by the river itself. Starting at Ayala Bridge the boundary line runs along Ayala Boulevard up to Concepcion Street. It follows this street until it reaches Isaac Peral Street. The line follows San Marcelino Street from Paco Cemetery along General Luna Street to Paco Bridge. From there, it follows southerly the Estero de Paco to the union of this canal with the one called "Tripa de Gallina," as far as Tejeron Street, from which point it follows northerly the Estero de Pandacan. No case of plague was found in this district. Rat-bite fever, however, must have been endemic in this district for many years, because the clinical report of a case of rat-bite fever by José Montes in 1923 gives the information that the patient resided in Paco district. One case of rat-bite fever was detected in Paco near the market in 1931.

On the outskirts of this district and on the southern shore of the river we find the residential district of Ermita, which continues into Malate, Santa Ana, and Pandacan. Santa Ana and Malate districts continue uninterruptedly into the suburbs of Pasay and Singalong. On the northern side the outskirts are a part of San Miguel, part of Sampaloc, Santa Mesa, and the most northern part of Tondo. No case of plague or rat-bite fever has ever been found in these residential districts of Manila.

DISCUSSION

Judging from the report of clinical cases of rat-bite fever by Manuel Guerrero in 1917, José Montes in 1923, and Ana Vazquez-Colet in 1931, we can safely state that rat-bite fever has been endemic in Manila for more than twenty years and the date of its introduction into Manila is beyond the interest of the present investigation. The Philippine Islands is one of the two countries, bordering on the Pacific Ocean, where plague is not endemic. The second country being Japan, it is significant that both countries are archipelagoes. This may be interpreted as the result

of efficient ship-quarantine service, particularly in view of the fact that, as in Japan, in the Philippine Islands plague has been introduced in one or another port, from time to time; so that it is reasonable to conclude that bubonic plague knocks at the gates of the Philippines more frequently than is generally suspected, but it rarely gets by the plague-preventive measures imposed on ships by the quarantine. Introduced as an outbreak in a port of the Philippines from time to time, it has never become endemic, the reason for which may be speculated upon but has not been clearly demonstrated.

Bearing both rat-bite fever outbreaks and bubonic-plague outbreaks in mind, we can define in the City of Manila a danger area. This danger area starts north on the bay shore with the wide Estero de Vitas and follows this canal as far as Tondo Market. From there eastward, it follows Tayuman Street including the railroad terminal and San Lazaro Hospital as far as San Lazaro Race Course. From this point the border line runs southward as far as Bilibid Prison, following Andalucia Street as far as Azcarraga Street. It follows Ascarraga to the point where this street crosses the Estero de San Miguel. It follows this canal in a southerly direction to the point where the estero turns westward. That is the point where Acasia Street crosses rectangularly General Solano Street, which is the continuation of Echague Street, and where it touches the river shore. Crossing the river, on the opposite side, the line begins on the river shore at the foot of and following Cristobal Street to its crossing of Isaac Peral Street and from Canonigo Street, Paco, the line follows southerly along Paz Street to the point where this street reaches the Estero de Paco. From that point the line commences at the Estero de Paco, follows Tennessee Street, turns at the crossing of Kansas northerly to General Luna Street. It follows General Luna as far as Burgos Street. It turns along this street westerly to Katigbak Drive and to the bay shore.

One glimpse at the map will show that the danger zone on the right, the northern shore, of the river is far larger in extent and includes the most densely populated districts of the City of Manila; consequently, it is the most-difficult part of Manila with regard to plague-suppression control. The danger area on the southern shore of Pasig River is smaller in extent. It consists of three sections, separated from each other, unlike the zone on the northern shore. We can see that the districts of Ermita, Ma-

late, Santa Ana, Pandacan, Santa Mesa, and the northeastern sections of Sampaloc and Tondo are outside the relative danger zone. Within this entire danger area, as outlined, there are particular danger foci where both rat-bite fever and plague have been found in humans or rats. They are, first, the water front bounded by Pasig River, by the bay shore, separated from Intramuros and other districts by wide open playgrounds. Second in importance is the entire San Nicolas district. Third is the portion of Intramuros bounded by Anda, Solana, Potenciana, and Cabildo Streets. It would be well to consider these districts as the first danger zone. This area is cuneiform due to the extension of the water front within the city along the river shores. Adjacent to the San Nicolas district, and as a second danger zone, is the Manila Railroad focus bounded by Azcarraga, Antonio Rivera, Juan Luna, and Fajardo Streets. The part of Binondo district that is bounded by the river, the Estero de Binondo, the Estero de la Reina as far north as Ongpin Street, and the Quiapo district, adjacent to the Estero de la Reina, bounded by the river front, the Estero de San Miguel following its northern branch as far as Carriedo Street including Plaza Miranda, are districts that may well be considered the second danger zone. The northern part of Tondo, as far as Tayuman Street, on the northern shore, and Paco district, starting with Paco Market as a center, may be well considered the third danger zone.

The findings made in the study of the distribution of rat-bite fever in Manila do not indicate the succession of the invasion by this disease of Manila districts. The disease evidently has become endemic in Manila. Plague is introduced into Manila from outside ports. However, the distribution of rat-bite fever shows that besides the districts visited usually by sporadic outbreaks of plague in Manila others may be successively invaded. Paco district, for instance, has never been known to be invaded by plague, yet cases of rat-bite fever were found there. This observation seems to be a hint that should rat plague spread again in Manila, it would undoubtedly follow the same routes as rat-bite fever did and Paco district in the neighborhood of the market is more likely to be invaded next to the usual foci of plague. Plague may spread farther on the southern shore of Pasig River from Paco district rather than from Intramuros or from the Port Area.

RECOMMENDATION

The main object of securing samples of rats in a city that is either infested or threatened with bubonic plague is to locate the foci of plague infection among rats. Thus further suppression measures, such as destruction of fleas and protection of inhabitants, can be intensified and concentrated in places where the greatest danger lies. The particular spots designated in our discussion as foci of greatest danger represent the points in the City of Manila where the contact between the human and the rat population is most intimate. They are places where rat-borne diseases have occurred repeatedly. It seems to be a matter of logical deduction to expect that trapping and poisoning of rats at these points, throughout the city, must lead to early detection of rat-plague infestation. It would seem, therefore, both rational and advantageous as well as economical to concentrate trapping of rats in the places of greatest danger; that is to say, in Manila, the Port Area, the Solana-Cabildo-Potenciana-Anda blocks, and the San Nicolas district, particularly along Santo Cristo, San Fernando, and Del Pan Streets, the surroundings of Tutuban Station and Quiapo and Paco Markets. The reduction of the rat population in these particular places would have as a consequence immigration of rats from the surrounding vicinity of these particular foci where food for rats abounds. Thus, with less financial outlay the greatest efficiency in locating the plague rats can be achieved. This holds particularly true during the offseason. In case that plague rats were found in the designated places, the rat-suppression measures could be extended from these foci fanlike through the vicinity. This seems to be a more-rational and less-expensive procedure than the plan that was used in the last plague epidemic in 1912–1914. Circles were drawn, then, through the City of Manila and trapping began on the periphery of the largest circle. From this outer circle the rat-destruction measures followed the radius up to a point where plague was detected among rats and the trapping was then extended sidewards from the intersection of the radius and the nearest circle. It was a very extensive and costly measure and, no previous information being available to the authorities, was the only one to follow. It brought forth information which, strengthened by the study of the rat-bite fever in recent times, should serve to develop a plan that would yield the

desired information more rapidly at far less expense to the Government.

As a matter of fact, the original plan of trapping rats along the circles and radii had to be abandoned when human plague broke out in various points in the city. The rat-control measures had to be concentrated at the places where human cases of plague occurred. At that time the trapping, performed in the vicinity of the foci of human plague, yielded little information as to rat infestation, for the obvious reason that previous to the occurrence of human cases the greatest bulk of the rats have succumbed to the plague epidemic and plague-infected rats were rarely found in the houses and dwellings of plague patients. The human cases, being a consequence of rat plague with a high rate of mortality among rats, naturally occurred weeks after the rat epidemic. The infected fleas left the dead rats and not being able to encounter their natural prey, since all the rats had died or had been killed, pressed by hunger attacked humans. The second phase of the rat control in 1912–1914 was far behind the possibility of finding plague-infected rats. The plan suggested by our investigation would undoubtedly detect plague rats sooner due to the fact that the places in which to locate the plague rats became known and the entire force of antiplague control could be concentrated in smaller areas under this plan rather than scattered over a large area in the entire city as was done under the plan of 1912–1914.

SUMMARY

A comparison is presented between the distribution of human plague and rat plague in the City of Manila in 1912–1914 on the one hand and the distribution of human cases of rat-bite fever in Manila in 1931–1932 on the other hand. A complete agreement as to the districts affected by plague and those affected by human rat-bite fever is pointed out by discussion of personal observations made by the senior author during the outbreaks of the two rat-borne diseases that occurred twenty years apart. A tentative prediction of the progress of rat plague in Manila is outlined and a plan of attack against rat plague is proposed that is based on the reoccurrence of the two rat-borne diseases in the same localities in the city. The usefulness of the study of the distribution of rat-bite fever in a city free from plague, but constantly threatened by invasion from neighboring ports, is emphasized.

TABLE 1.—*Showing the results of experiments concerning the viability of Spirochæta morsus muris.*

Designation of guinea pig.	Body weight.	Temperature.	Time of exposure.	Date of inoculation.	Spirochætes found for the first time.
	g.	*°C.*	*Hours.*		
RB-27	270	26-27	[a]	VIII-20-31	IX- 2-31
RB-29	350	26-27	0.5	VIII-20-31	IX- 3-31
RB-49	370	26-27	1	VIII-20-31	IX-17-31
RB-30	300	26-27	2	VIII-20-31	VIII-31-31
RB-31	350	26-27	3	VIII-20-31	IX- 2-31
RB-32	300	26-27	4	VIII-20-31	IX- 3-31
RB-56	400	29-31	4	IX-4-31	IX-18-31
RB-57	650	29-31	6	IX-4-31	IX-18-31
RB-58	350	29-31	8	IX-4-31	IX-18-31
RB-59	550	<8	4	IX-4-31	IX-22-31
RB-60	500	<8	6	IX-4-31	IX-18-31
RB-61	250	<8	8	IX-4-31	IX-29-31
RB-62	700	37	4	IX-4-31	IX-22-31
RB-63	600	37	6	IX-4-31	IX-15-31
RB-64	750	37	8	IX-4-31	IX-15-31
RB-81	250	<8	8	X-6-31	X-24-31
RB-84	350	<8	24	X-7-31	None.
RB-87	300	<8	30	X-7-31	None.
RB-82	300	37	8	X-6-31	XI-24-31
RB-85	350	37	24	X 7-31	None.
RB-88	300	37	30	X-7-31	None.
RB-83	350	29-31	8	X-6-31	X-30-31
RB-86	250	29-31 24-29	24	X-7-31	None.
RB-89	320	29-31 24-29	30	X-7-31	None.

[a] Immediately.

TABLE 2.—*Results of search for Spirochæta morsus muris in the blood of inoculated Philippine monkeys.*

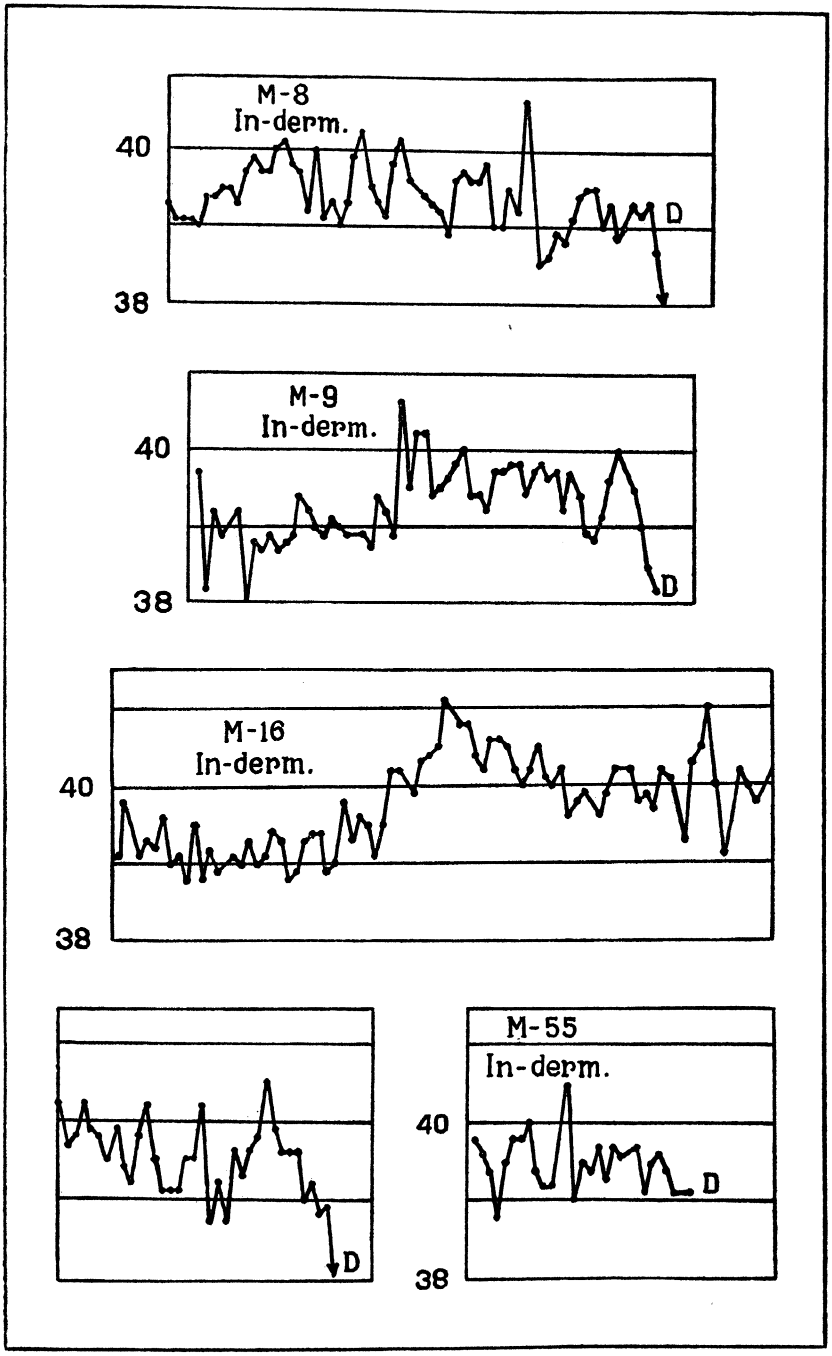
Designation of monkey.	Blood withdrawn, days after inoculation.	Recipient animal.	Spirochætes found.
	Days.		
Rb-6	8	Ms-19	No.
Rb-4 [a]	9	Ms-10	Yes.
Rb-20	9	M-100	
Rb-5 [a]	14	Ms-12	No.[b]
Rb-J-11	14	Ms-13	Yes.
Rb-1	17	Ms-7	Yes.
Rb-16 [a]	17	M-69	No.
Rb-18 [a]	23	M-72	No.
Rb-10	24	M-46	Yes.
Rb-15 [a]	29	Ms-45	No.
Rb-12	30	Ms-44	No.
Rb-Syp-25	59	Ms-16	Yes.
Rb-J-11	69 after first infection	M-15	Yes.
Do	13 after superinfection		
Rb-Syp-25	86 after first infection	M-13	No.
Do	11 after superinfection		
Do	143 after first infection	M-44	No.
Do	68 after superinfection		
Rb-Syp-25 [a]	219 after first infection	M-71	No.
Do	144 after first superinfection		
Do	67 after second superinfection		
Rb-3	88	M-14	No.
Rb-8 [a]	116	M-101	No.
Rb-7	127	M-104	

[a] Blood taken at autopsy. [b] Died the fourth day.

TABLE 3.—*Results of preventive chemotherapy in experimental rat-bite fever.*

[+, Infection developed; —, infection did not develop.]

Designation of guinea pig.	Drug.	Dose.	Result.	Controls.
M-133	Stibenyl	0.03 g	+	+
M-134	do	0.02 g	+	+
M-135	do	0.01 g	+	+
M-74	do	0.01 g	+	+
M-136	Antimosan	2 cc	+	+
M-137	do	1 cc	+	+
M-138	Quinine-iodo-bismuthate	0.025 g	+	+
M-139	do	0.0125 g	+	+
M-75	Stibosan	0.005 g	+	+
M-108	do	0.01 g	—	+
M-109	do	0.03 g	—	+
M-110	do	0.05 g	—	+



M-8
In-derm.
40
38
D
M-9
In-derm.
40
38
D
M-16
In-derm.
40
38
D
M-55
In-derm.
40
38
D

FIG. 2.

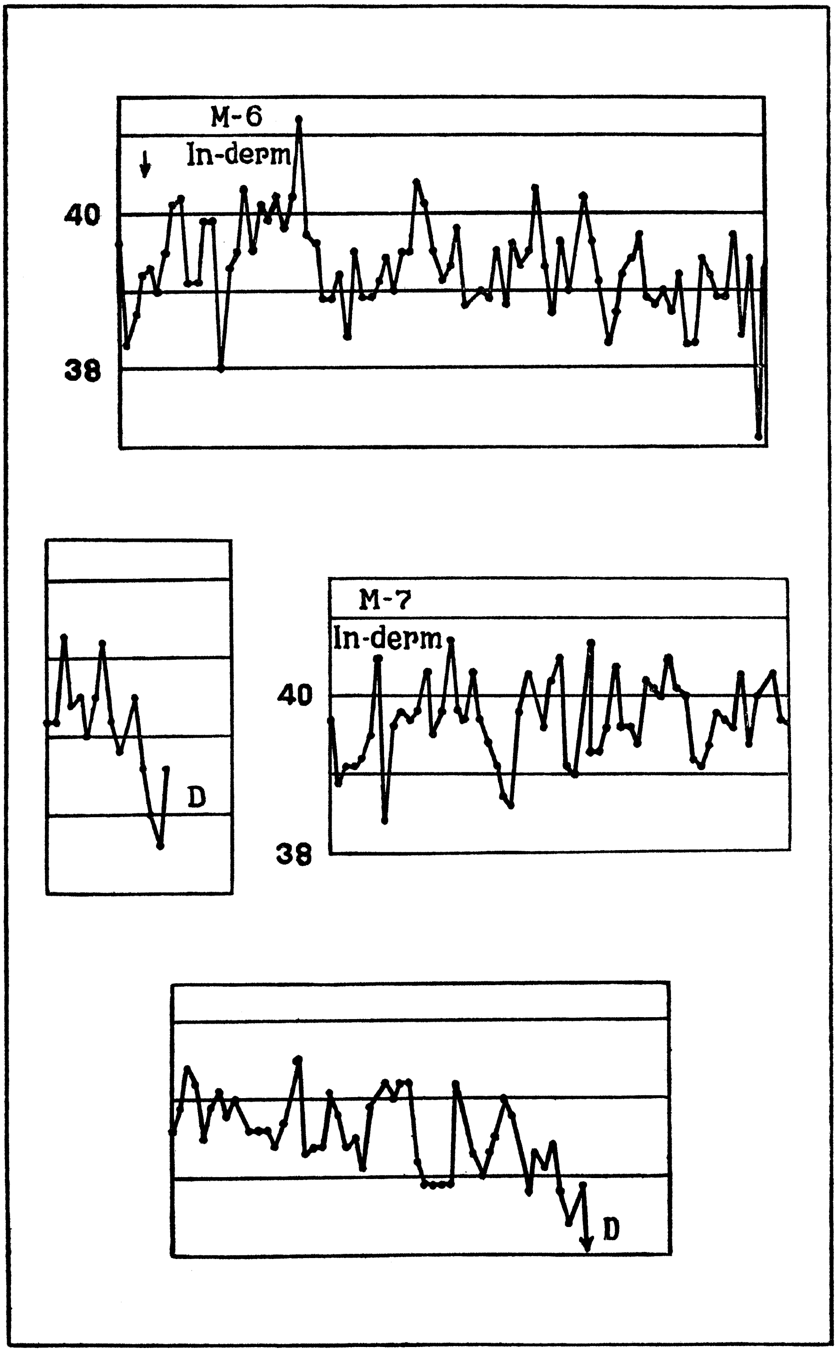


FIG. 3.

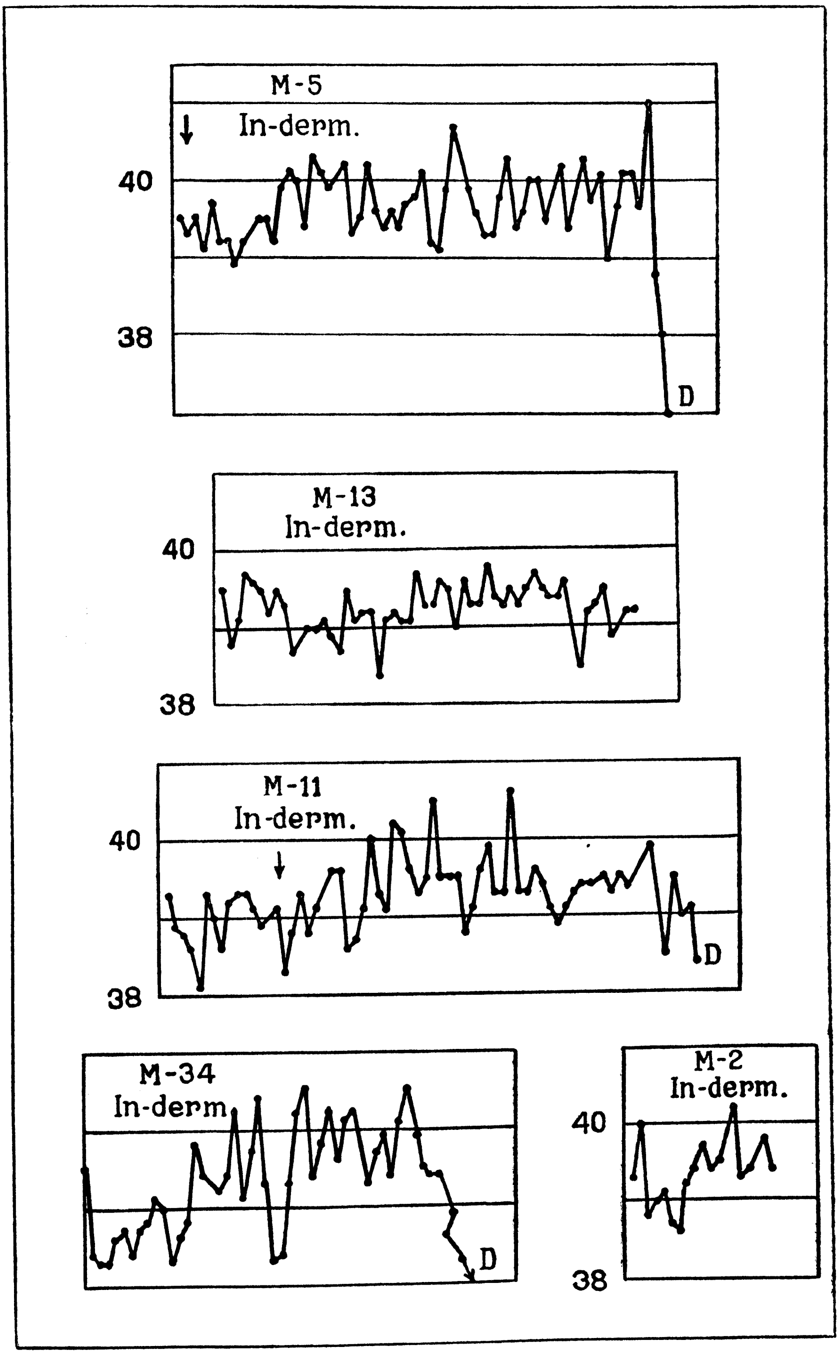

M-5
In-derm.
40
38
D
M-13
In-derm.
40
38
M-11
In-derm.
40
38
D
M-34
In-derm
D
M-2
In-derm.
40
38

FIG. 4.

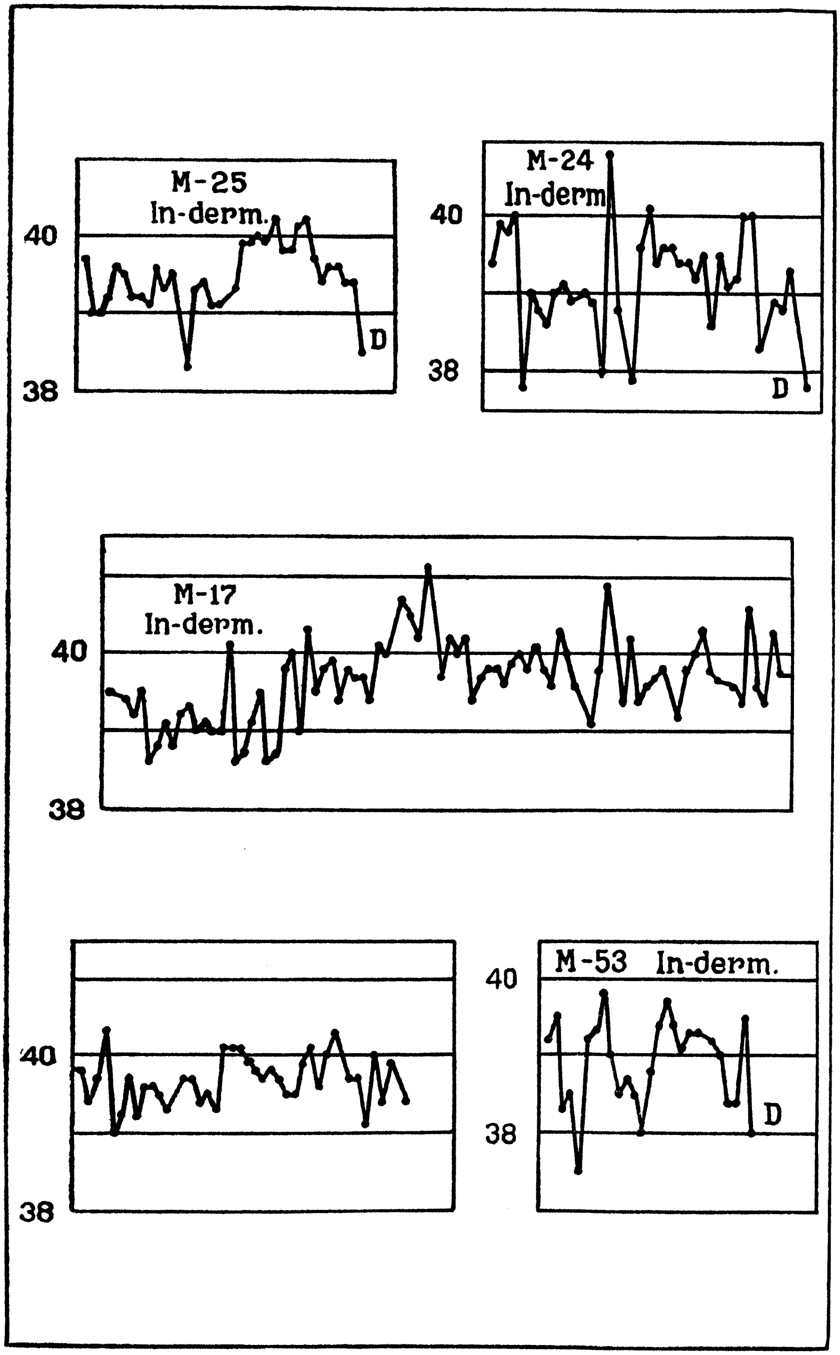
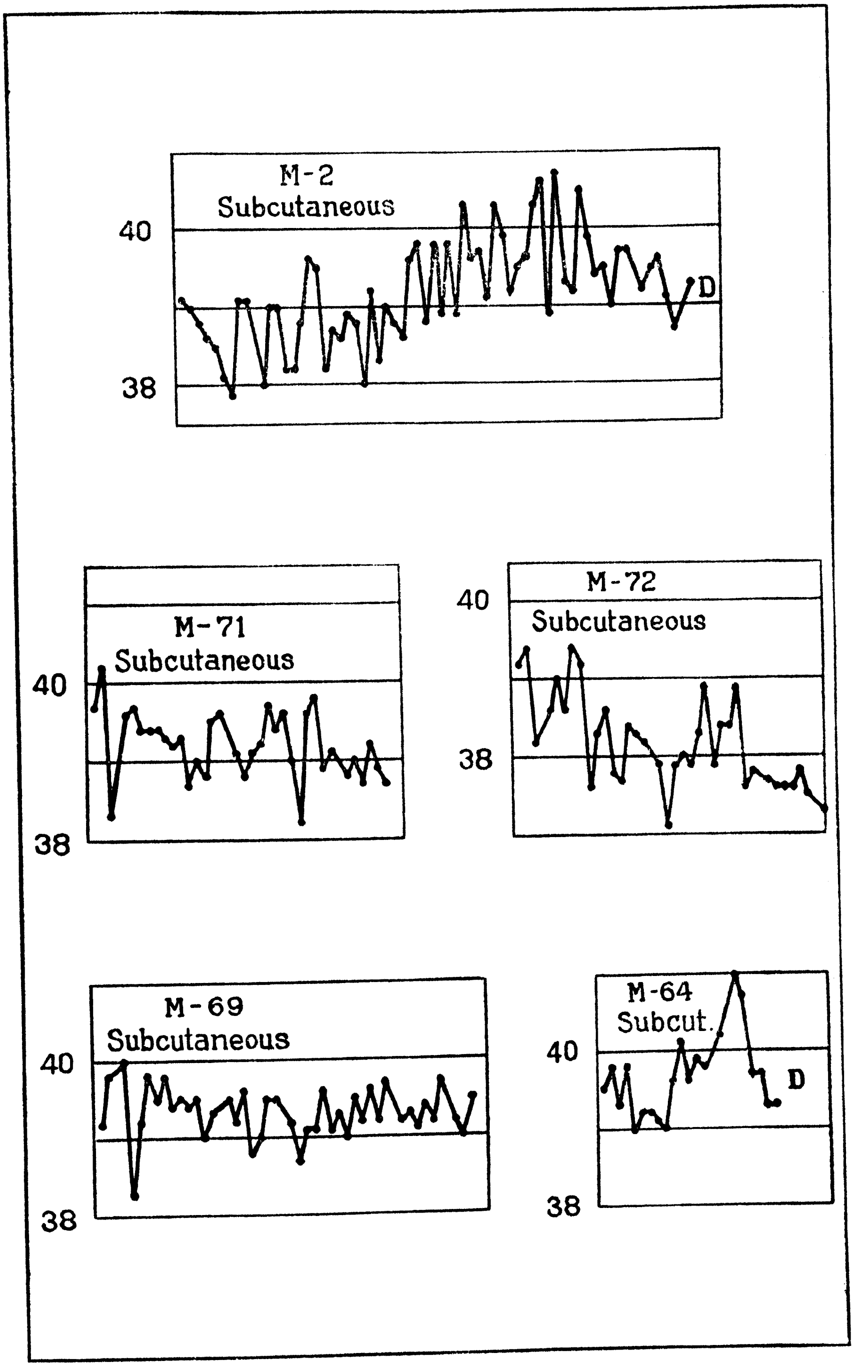

M-25
In-derm.
40
38
D
M-24
In-derm
40
38
D
M-17
In-derm.
40
38
40
38
M-53 In-derm.
40
38
D

FIG. 5.



M-2
Subcutaneous
40
38
D
M-71
Subcutaneous
40
38
M-72
Subcutaneous
40
38
M-69
Subcutaneous
40
38
M-64
Subcut.
40
38
D

FIG. 6.

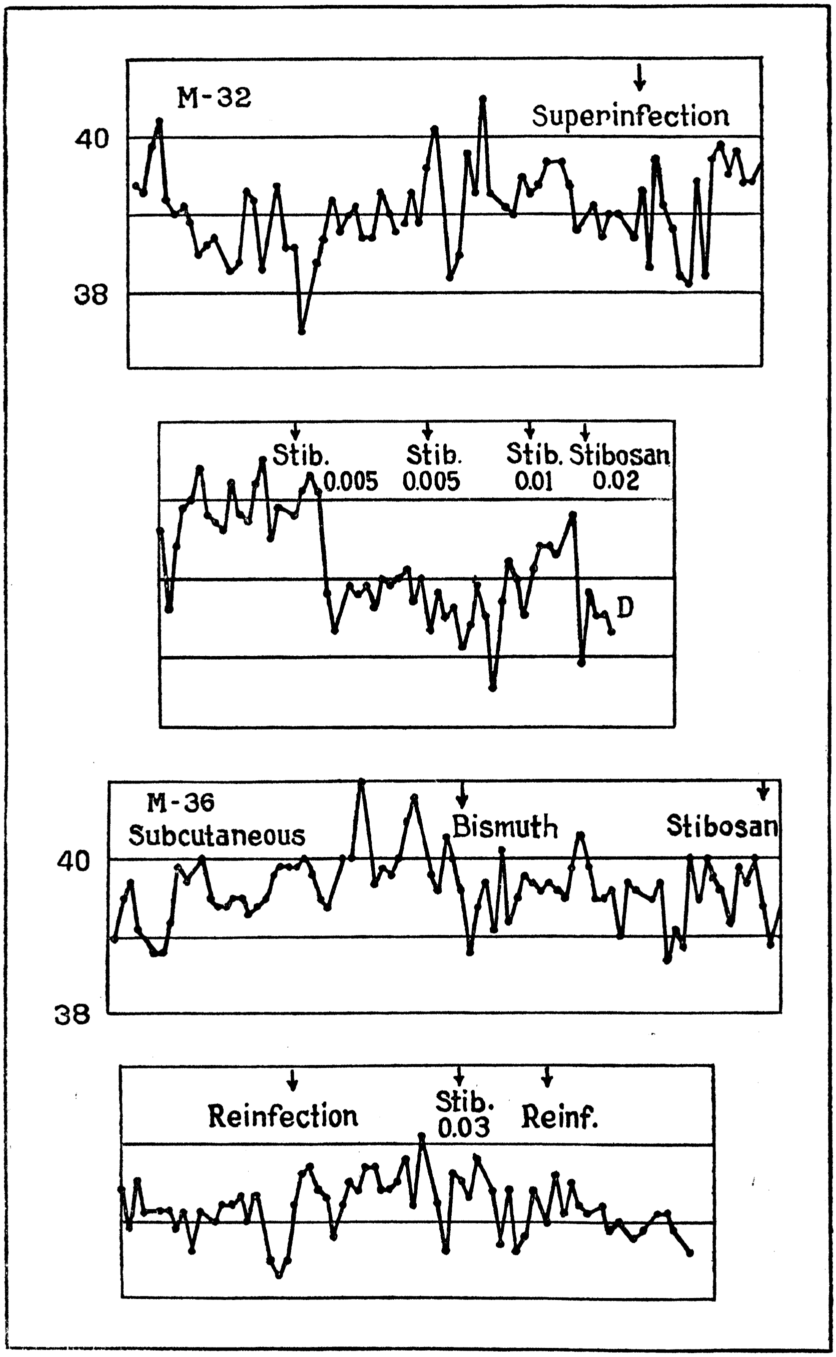

M-32
Superinfection
40
38
Stib. 0.005
Stib. 0.005
Stib. 0.01
Stibosan 0.02
D
M-36
Subcutaneous
Bismuth
Stibosan
40
38
Reinfection
Stib. 0.03
Reinf.

FIG. 7.

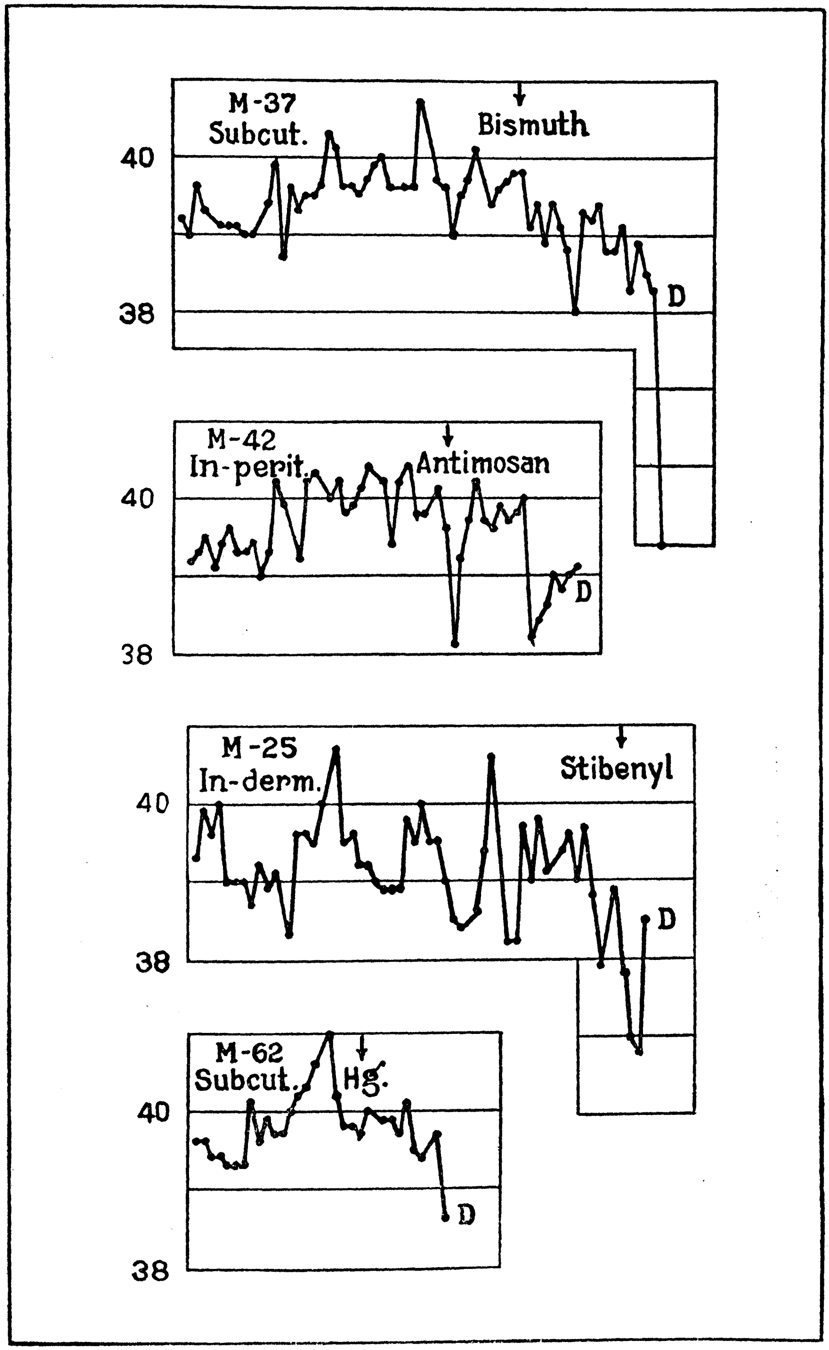

M-37
Subcut.
Bismuth
40
38
D
M-42
In-perit.
Antimosan
40
38
D
M-25
In-derm.
Stibenyl
40
38
D
M-62
Subcut.
Hg.
40
38
D

FIG. 8.

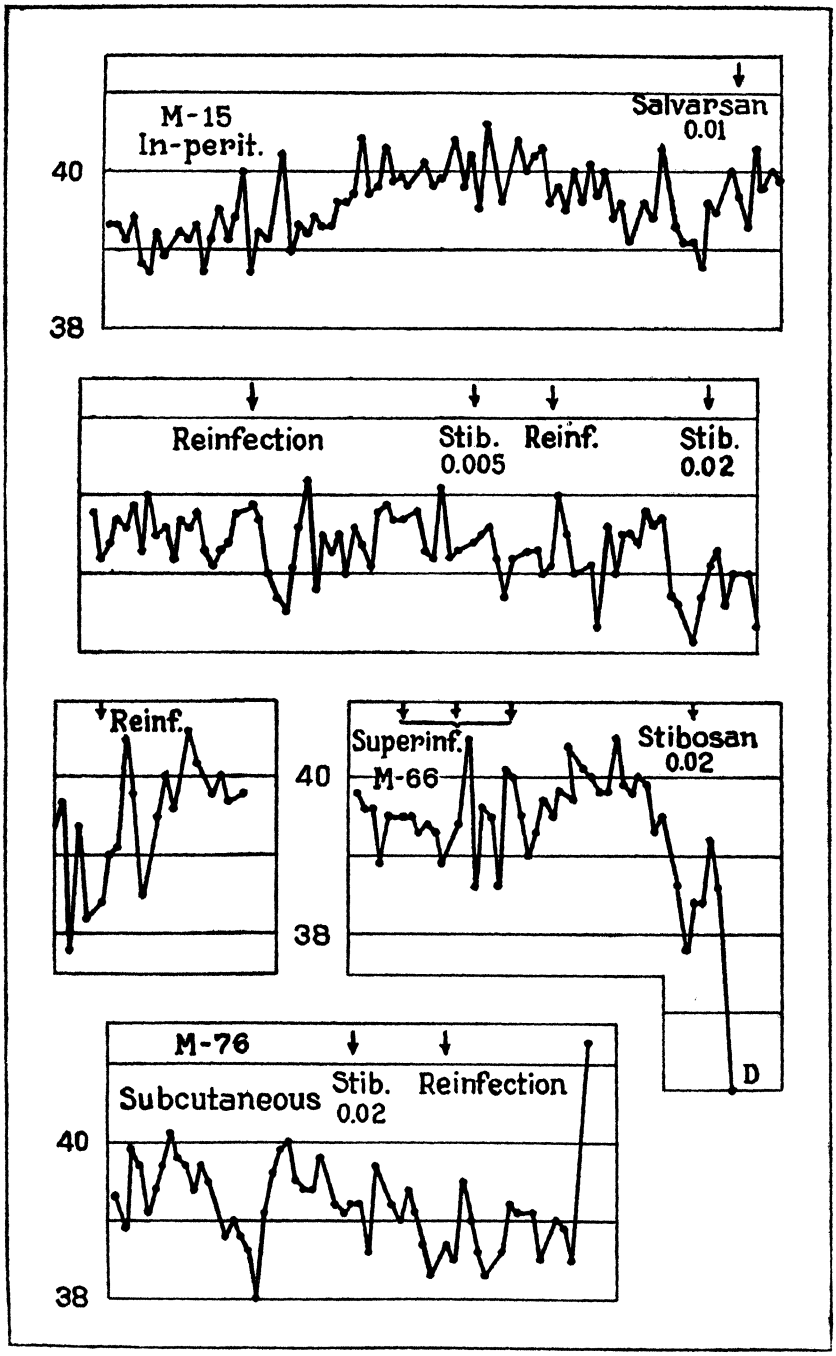

M-15
In-perit.
Salvarsan
0.01
40
38
Reinfection
Stib.
0.005
Reinf.
Stib.
0.02
Reinf.
40
38
Superinf.
M-66
Stibosan
0.02
D
M-76
Subcutaneous
Stib.
0.02
Reinfection
40
38

FIG. 9.

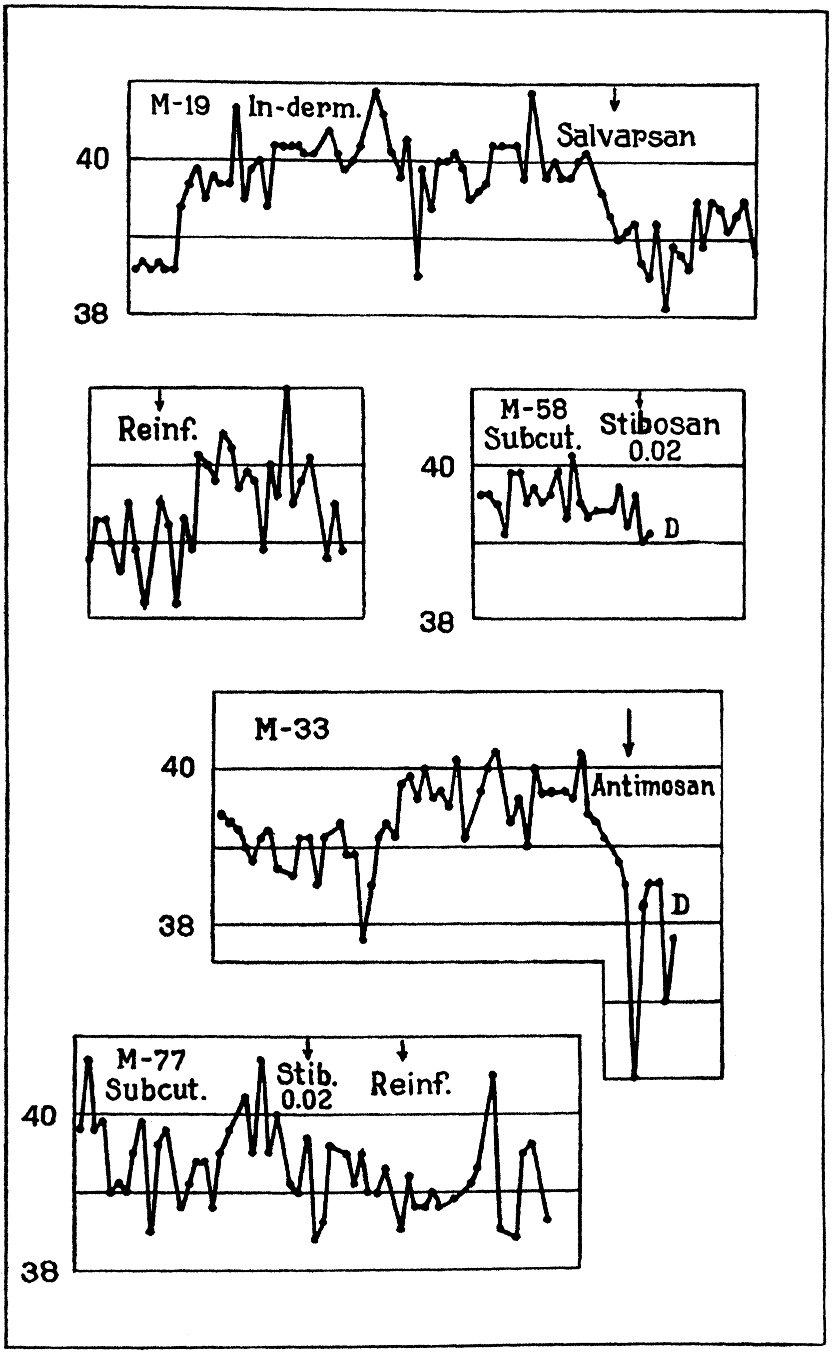

M-19
In-derm.
Salvarsan
40
38
Reinf.
M-58
Subcut.
Stibosan
0.02
40
D
38
M-33
40
Antimosan
38
D
M-77
Subcut.
Stib.
0.02
Reinf.
40
38

FIG. 10

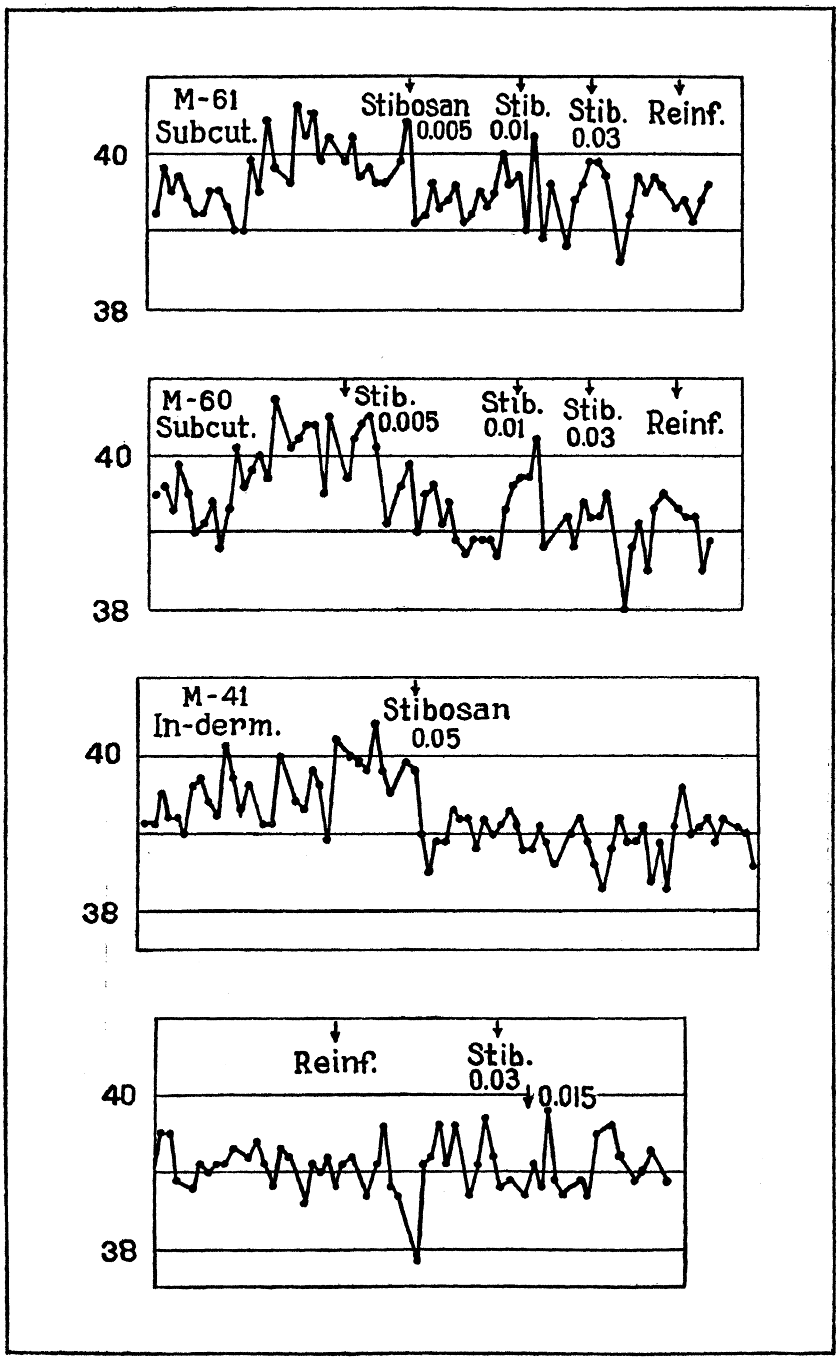

M-61
Subcut.
Stibosan
0.005
Stib.
0.01
Stib.
0.03
Reinf.
40
38
M-60
Subcut.
Stib.
0.005
Stib.
0.01
Stib.
0.03
Reinf.
40
38
M-41
In-derm.
Stibosan
0.05
40
38
Reinf.
Stib.
0.03
0.015
40
38

FIG. 11.

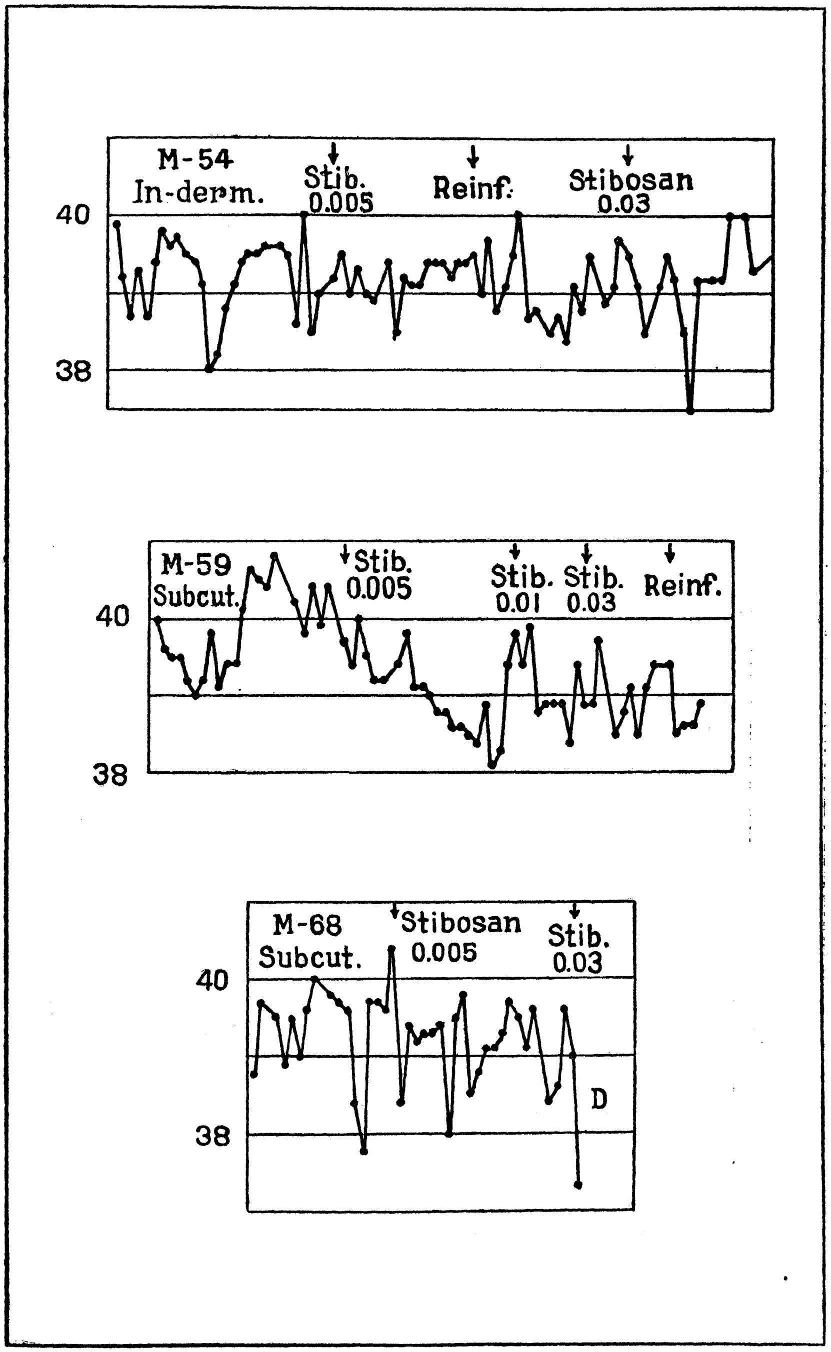

M-54
In-derm.
Stib.
0.005
Reinf.
Stibosan
0.03
40
38
M-59
Subcut.
Stib.
0.005
Stib.
0.01
Stib.
0.03
Reinf.
40
38
M-68
Subcut.
Stibosan
0.005
Stib.
0.03
D
40
38

FIG. 12.

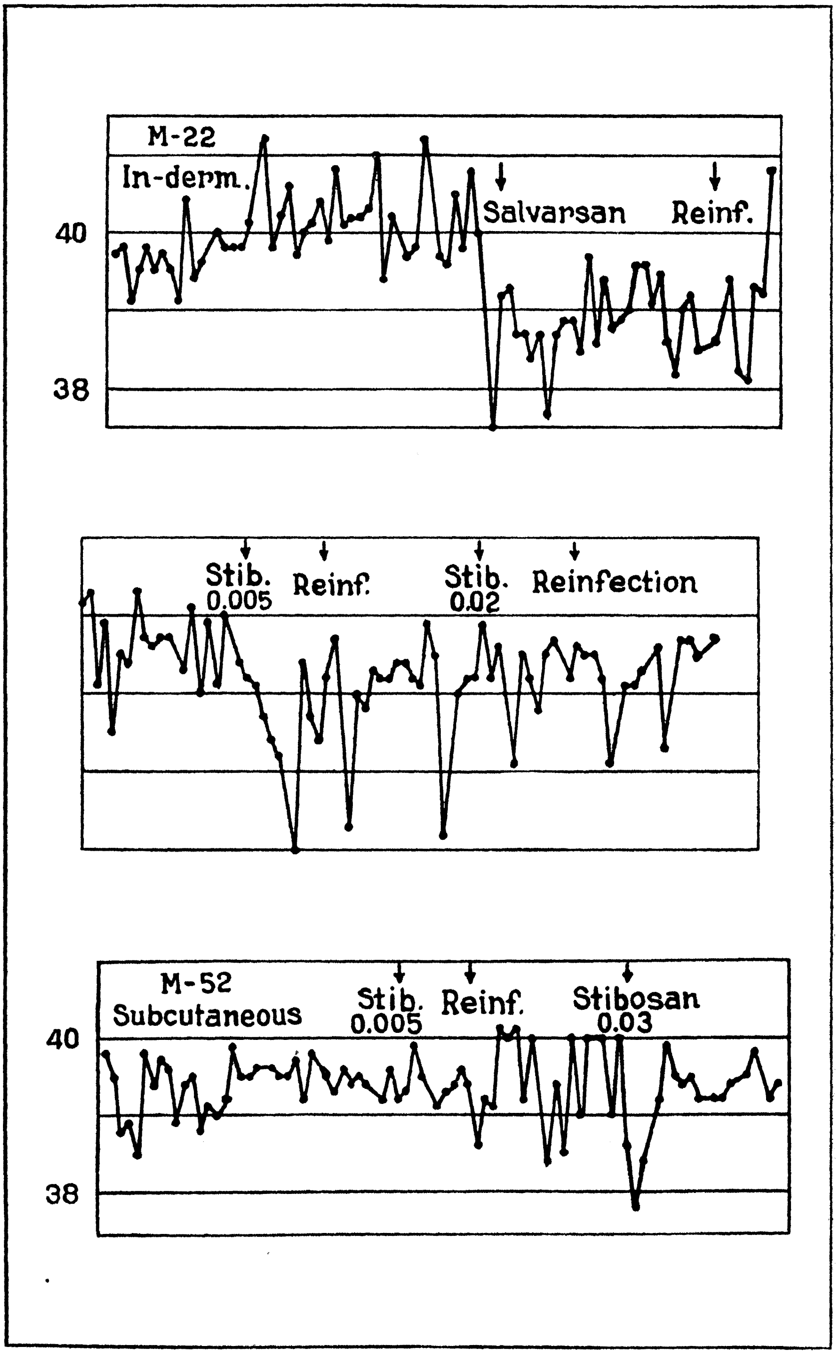

M-22
In-derm.
40
38
Salvarsan
Reinf.
Stib.
0.005
Reinf.
Stib.
0.02
Reinfection
M-52
Subcutaneous
40
38
Stib.
0.005
Reinf.
Stibosan
0.03

FIG. 13.

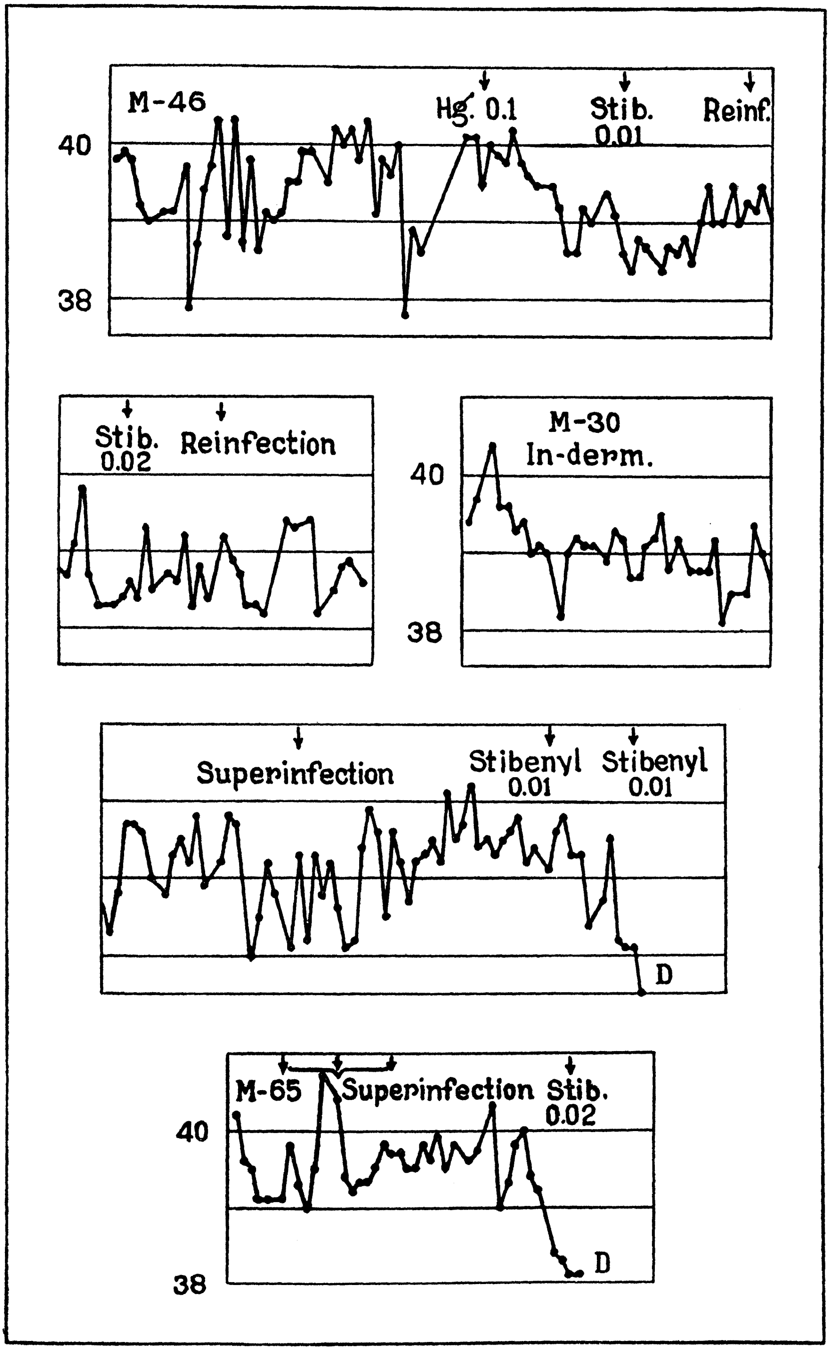

M-46
Hg. 0.1
Stib. 0.01
Reinf.
40
38
Stib. 0.02
Reinfection
M-30
In-derm.
40
38
Superinfection
Stibenyl 0.01
Stibenyl 0.01
D
M-65
Superinfection
Stib. 0.02
40
38
D

FIG. 14.

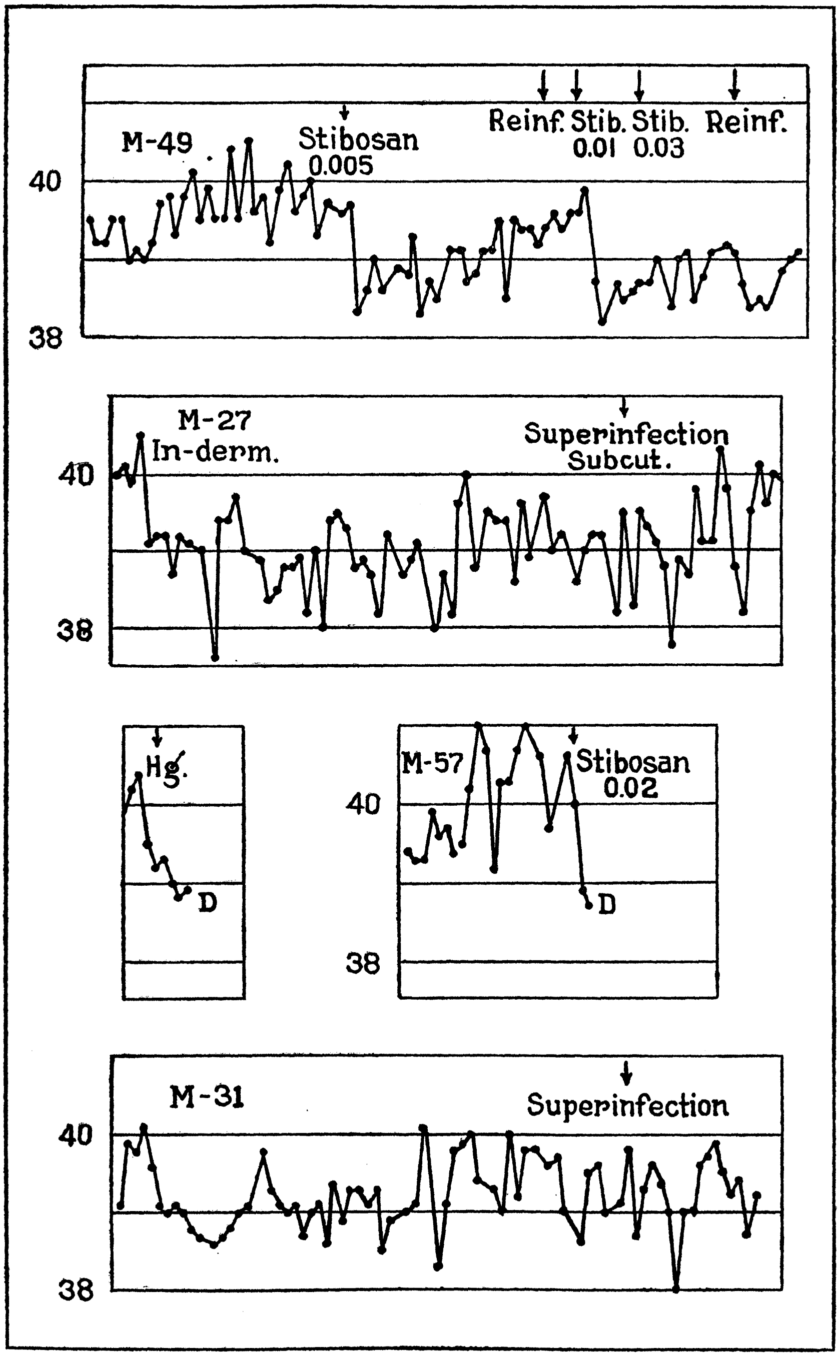

M-49
Stibosan
0.005
Reinf.
Stib.
0.01
Stib.
0.03
Reinf.
40
38
M-27
In-derm.
Superinfection
Subcut.
40
38
Hg.
D
M-57
Stibosan
0.02
40
D
38
M-31
Superinfection
40
38

FIG. 15.

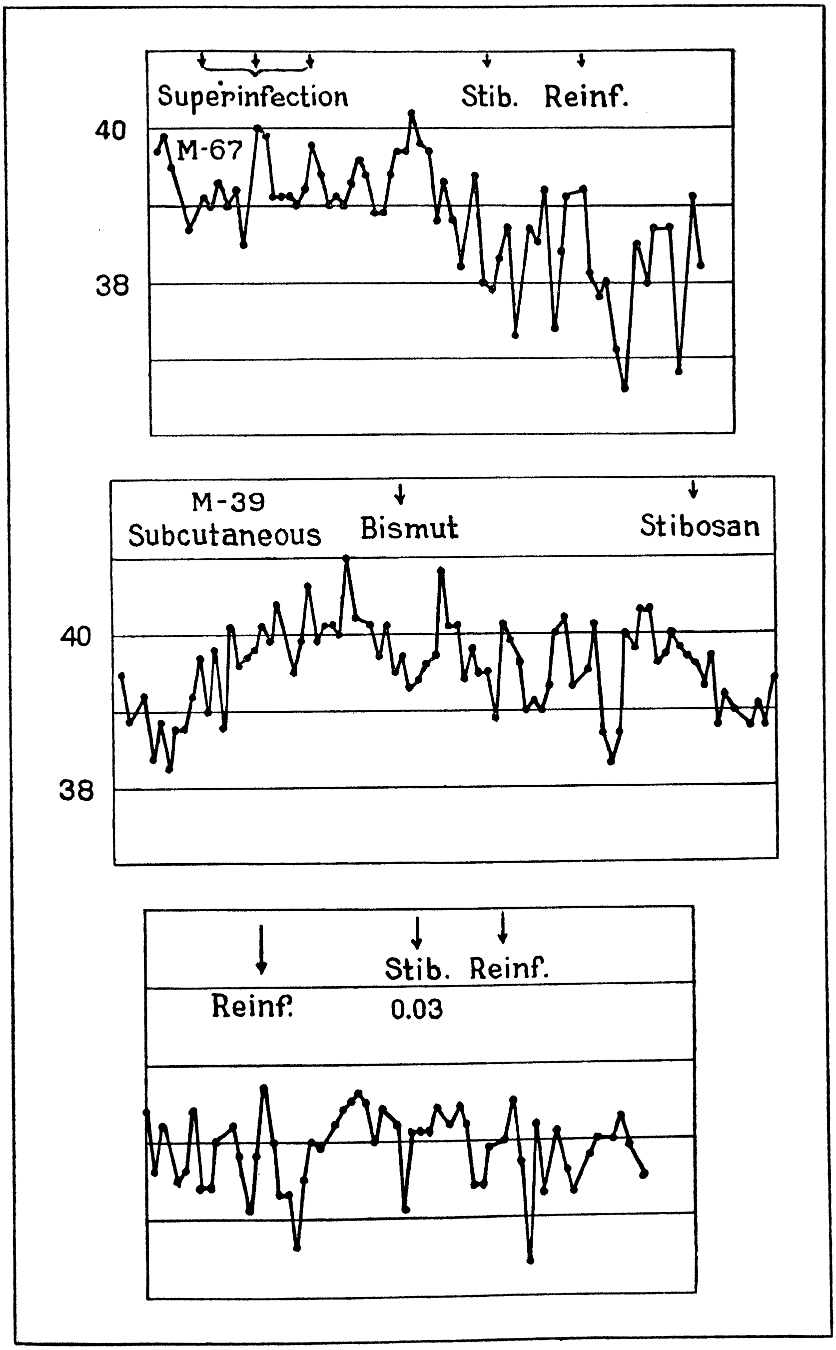
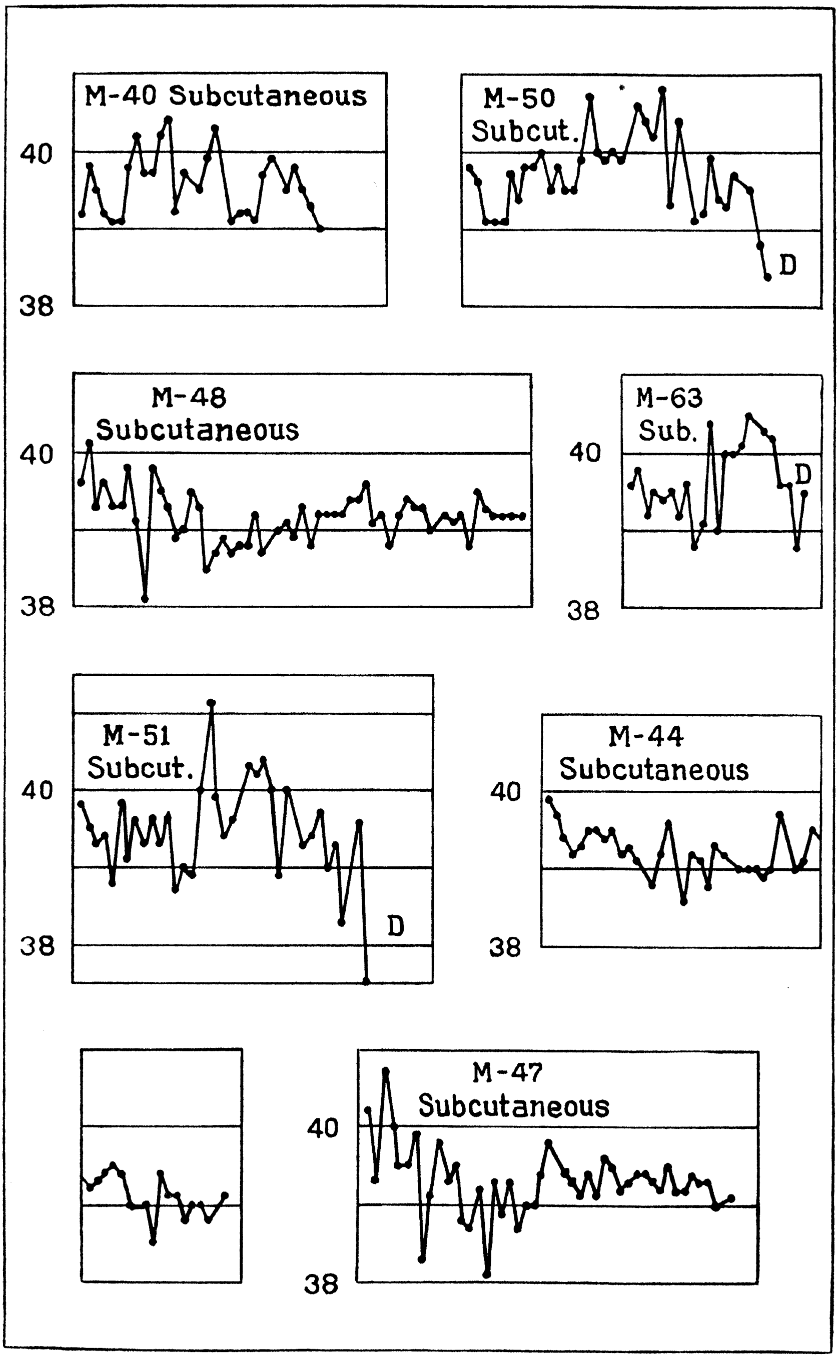

Superinfection
Stib.
Reinf.
40
M-67
38
M-39
Subcutaneous
Bismut
Stibosan
40
38
Stib.
Reinf.
Reinf.
0.03

FIG. 16.



M-40 Subcutaneous
40
38
M-50
Subcut.
D
M-48
Subcutaneous
40
38
M-63
Sub.
40
D
38
M-51
Subcut.
40
D
38
M-44
Subcutaneous
40
38
40
M-47
Subcutaneous
38

FIG. 17.

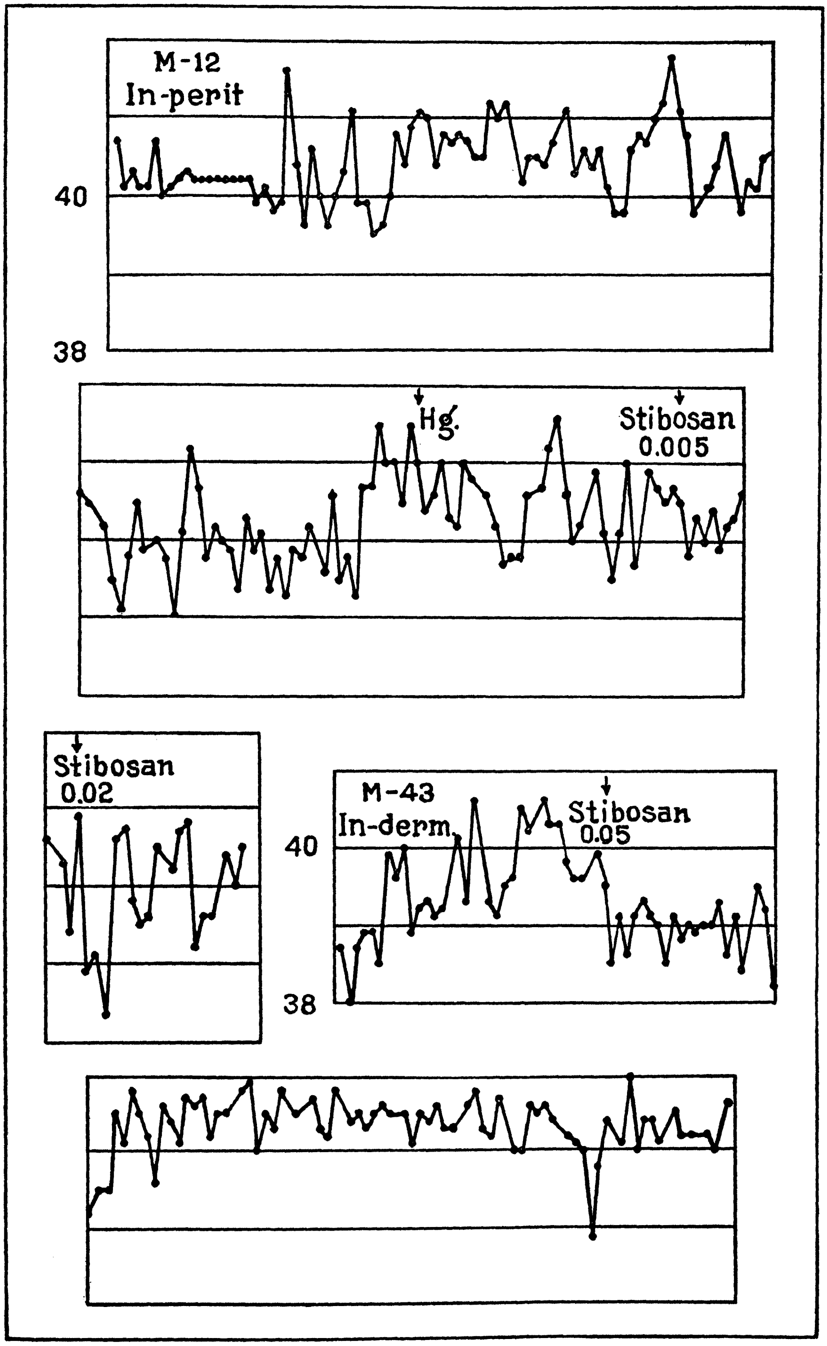

M-12
In-perit
40
38
Hg.
Stibosan
0.005
Stibosan
0.02
M-43
In-derm.
Stibosan
0.05
40
38

FIG. 18.

ILLUSTRATIONS

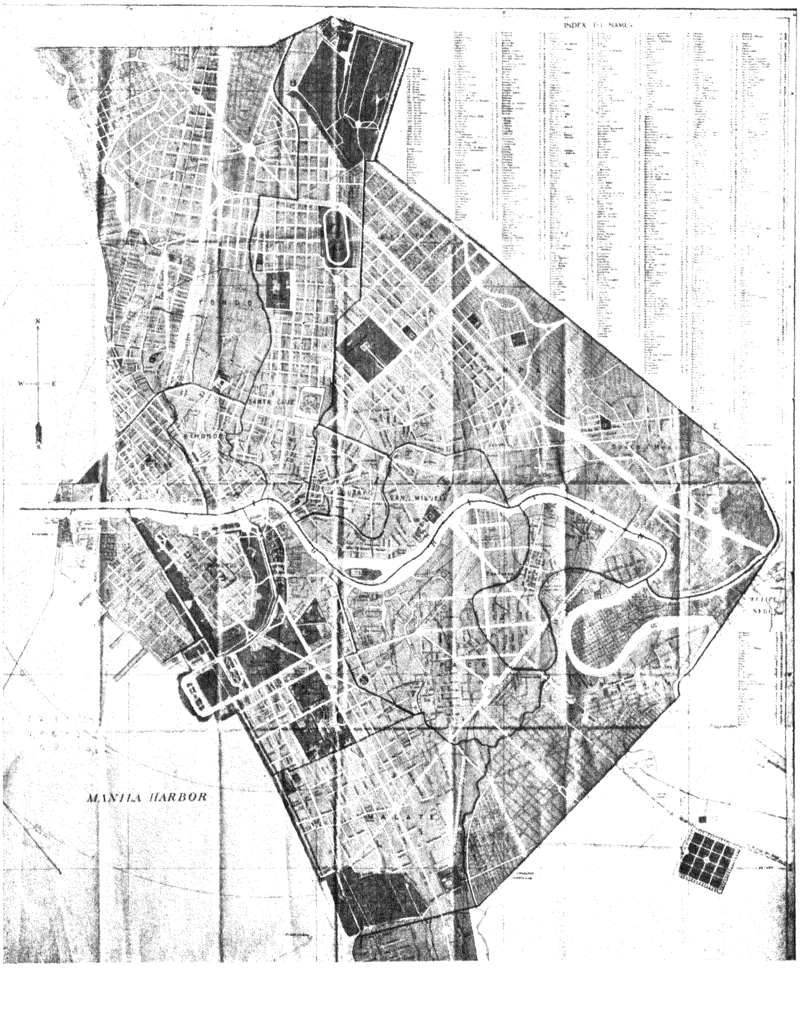


PLATE 1.

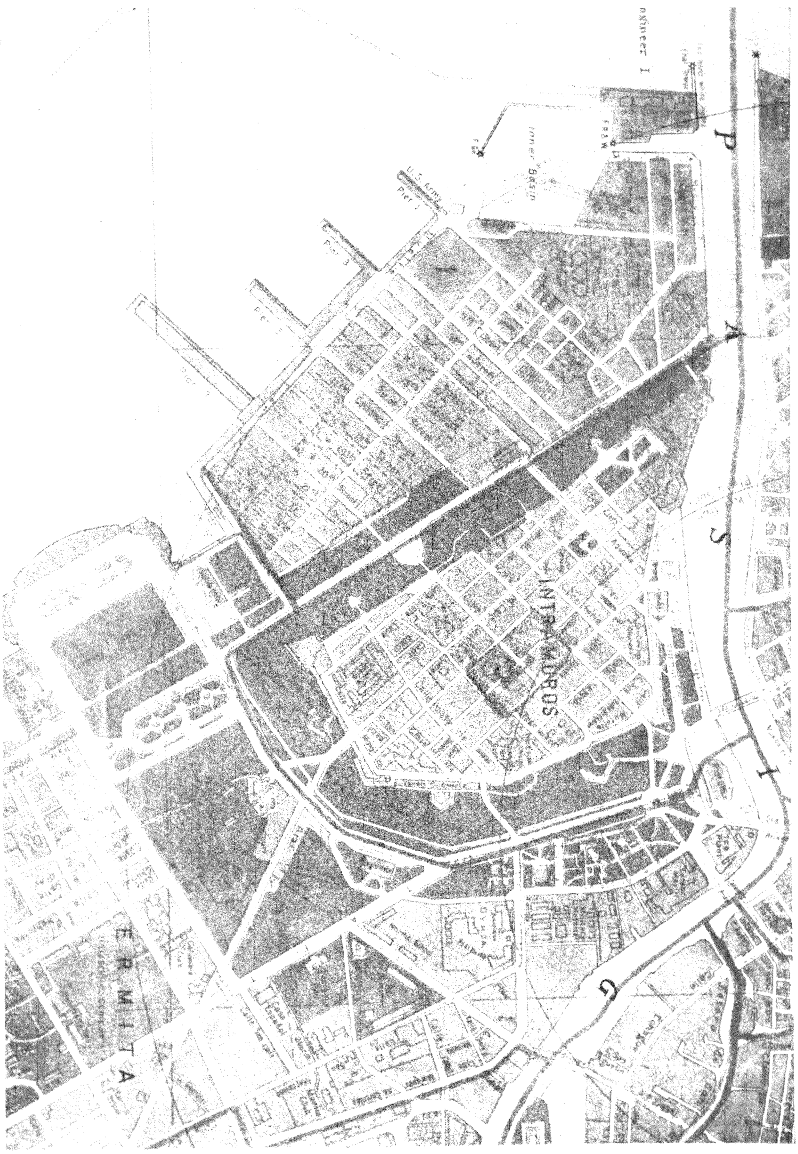


PLATE 2.

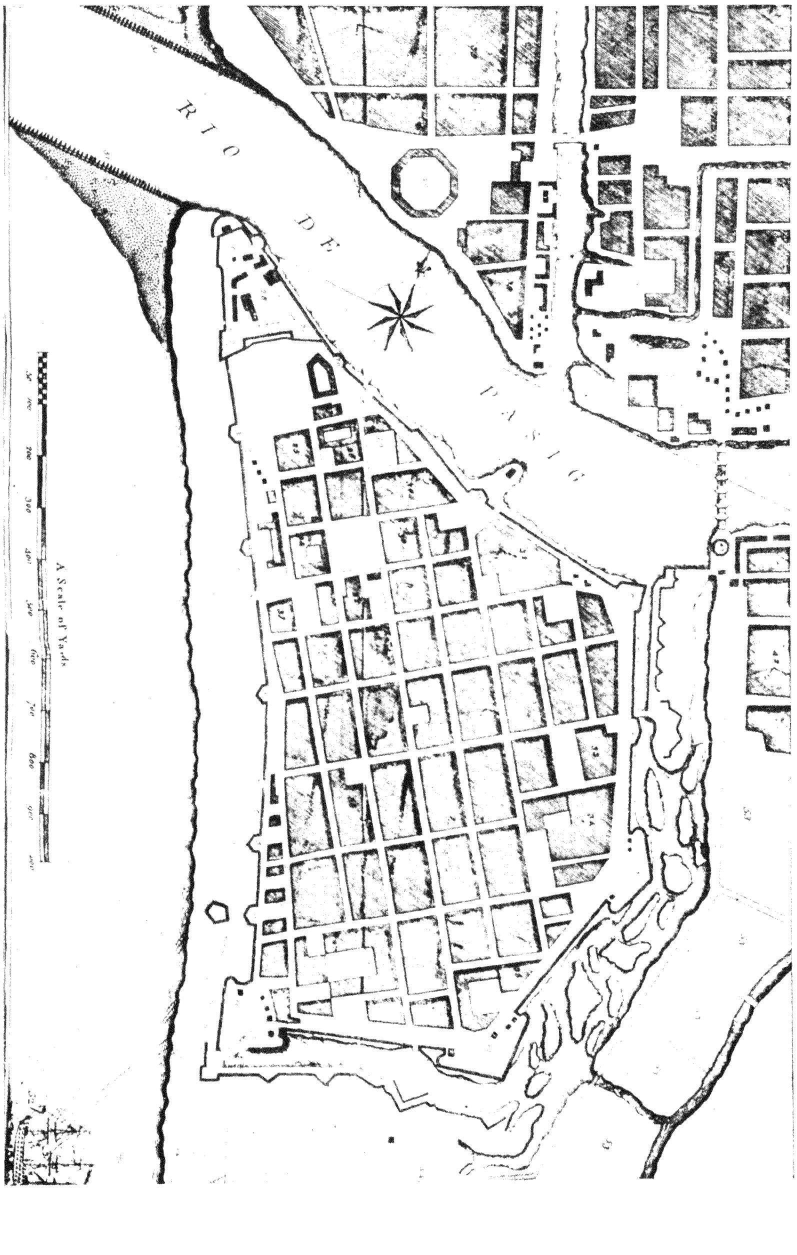


PLATE 3.

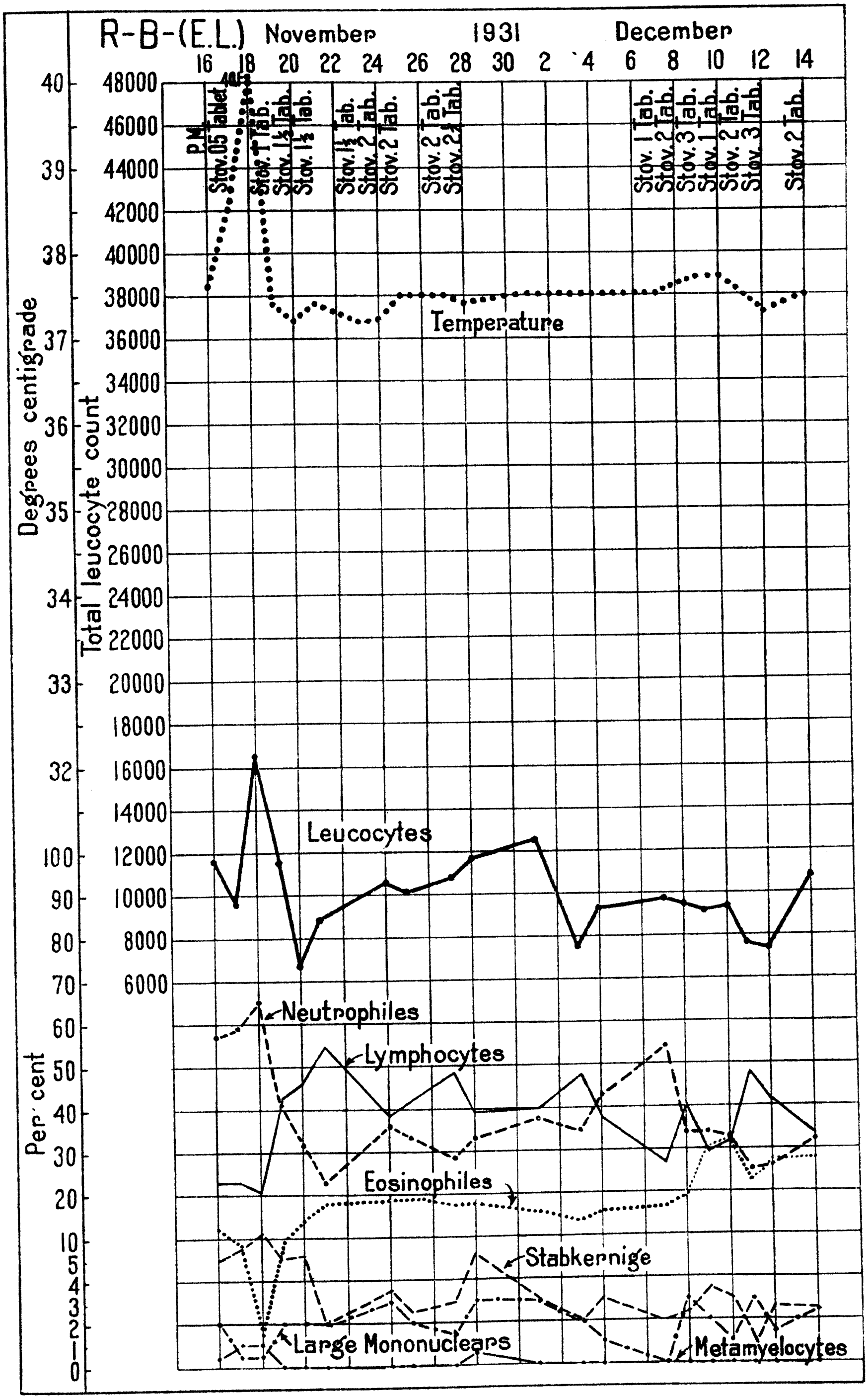


PLATE 4. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-(E.L.).

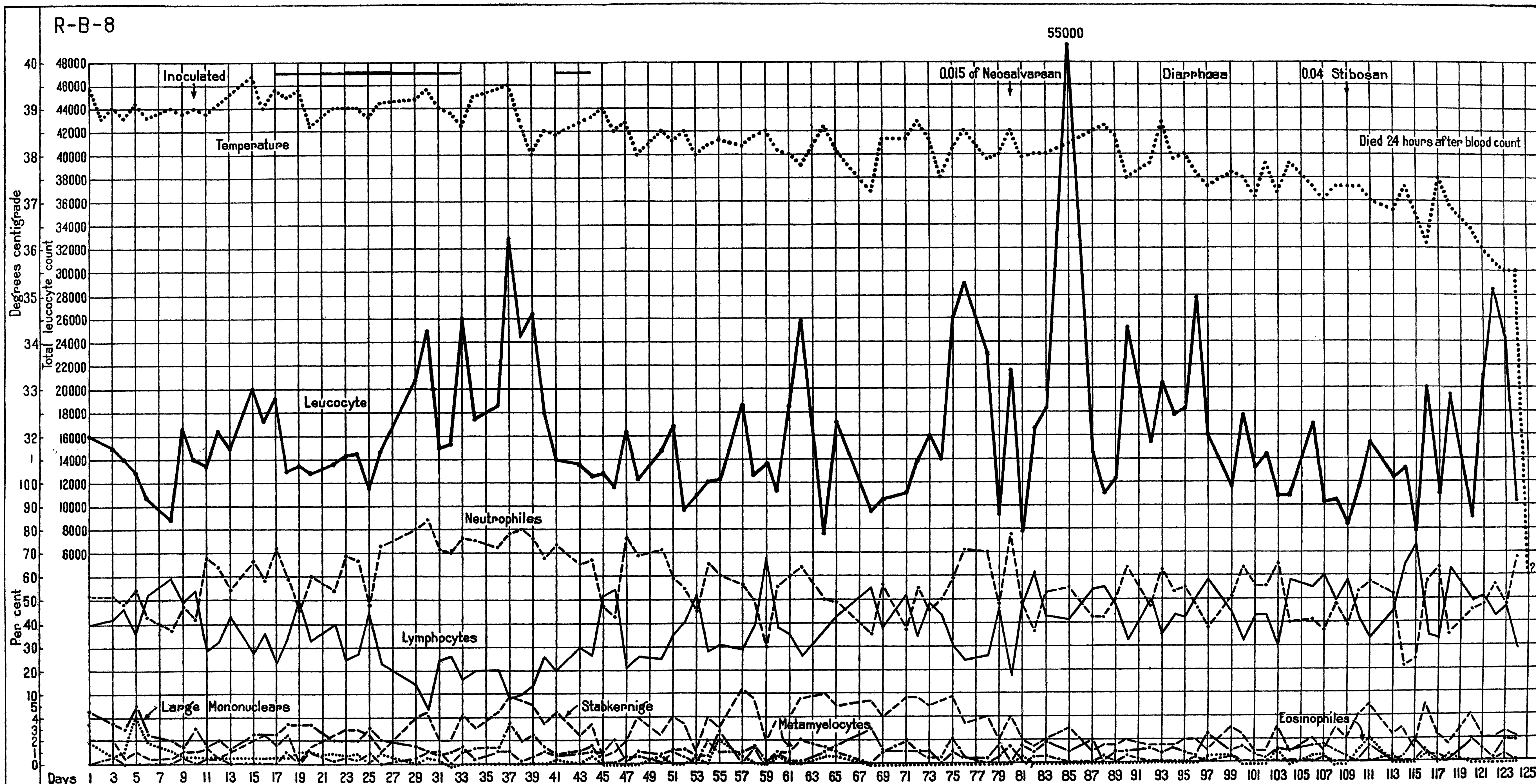


PLATE 5. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-8.

PLATE 6. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-9.

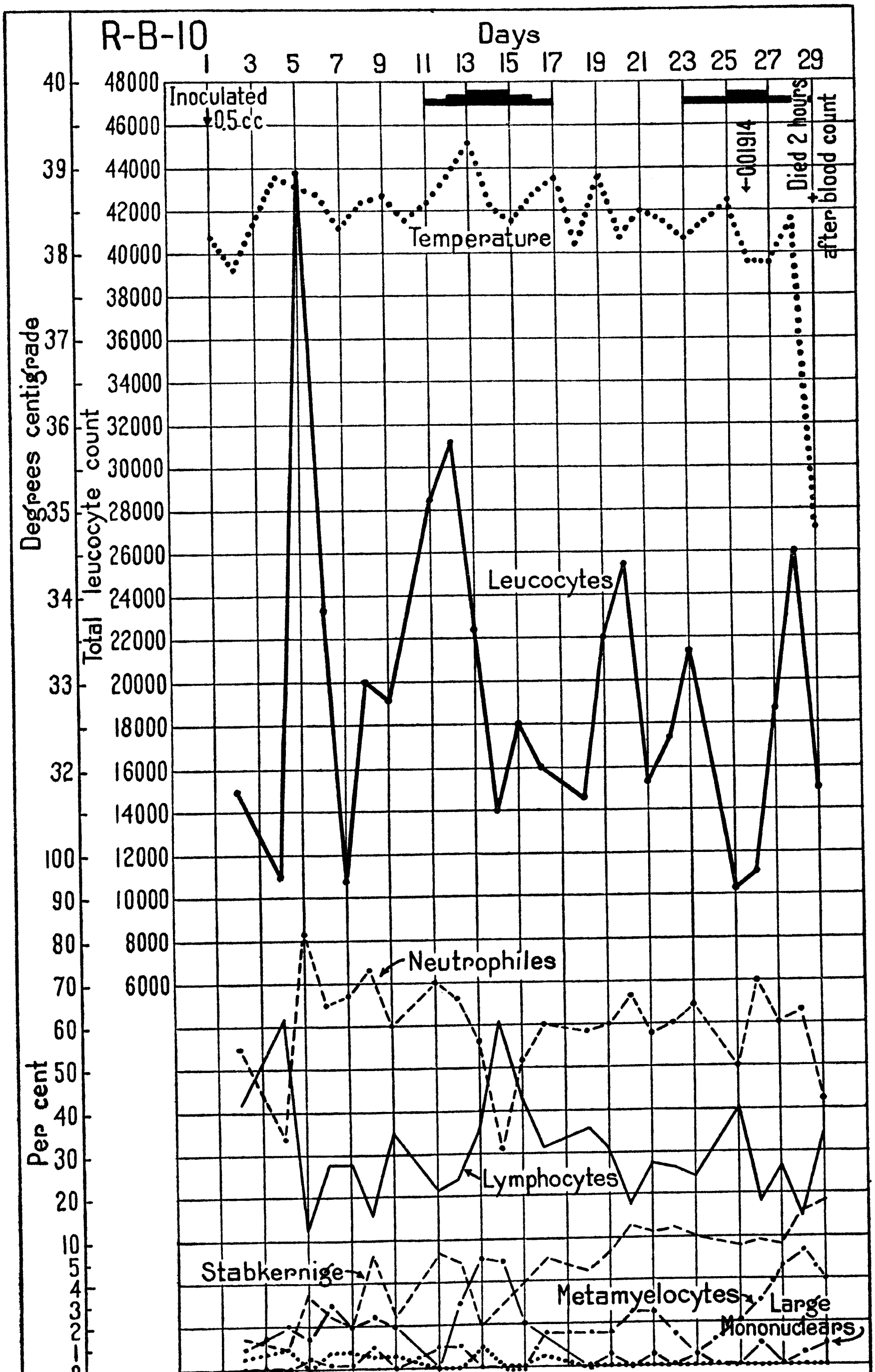


PLATE 7. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-10.

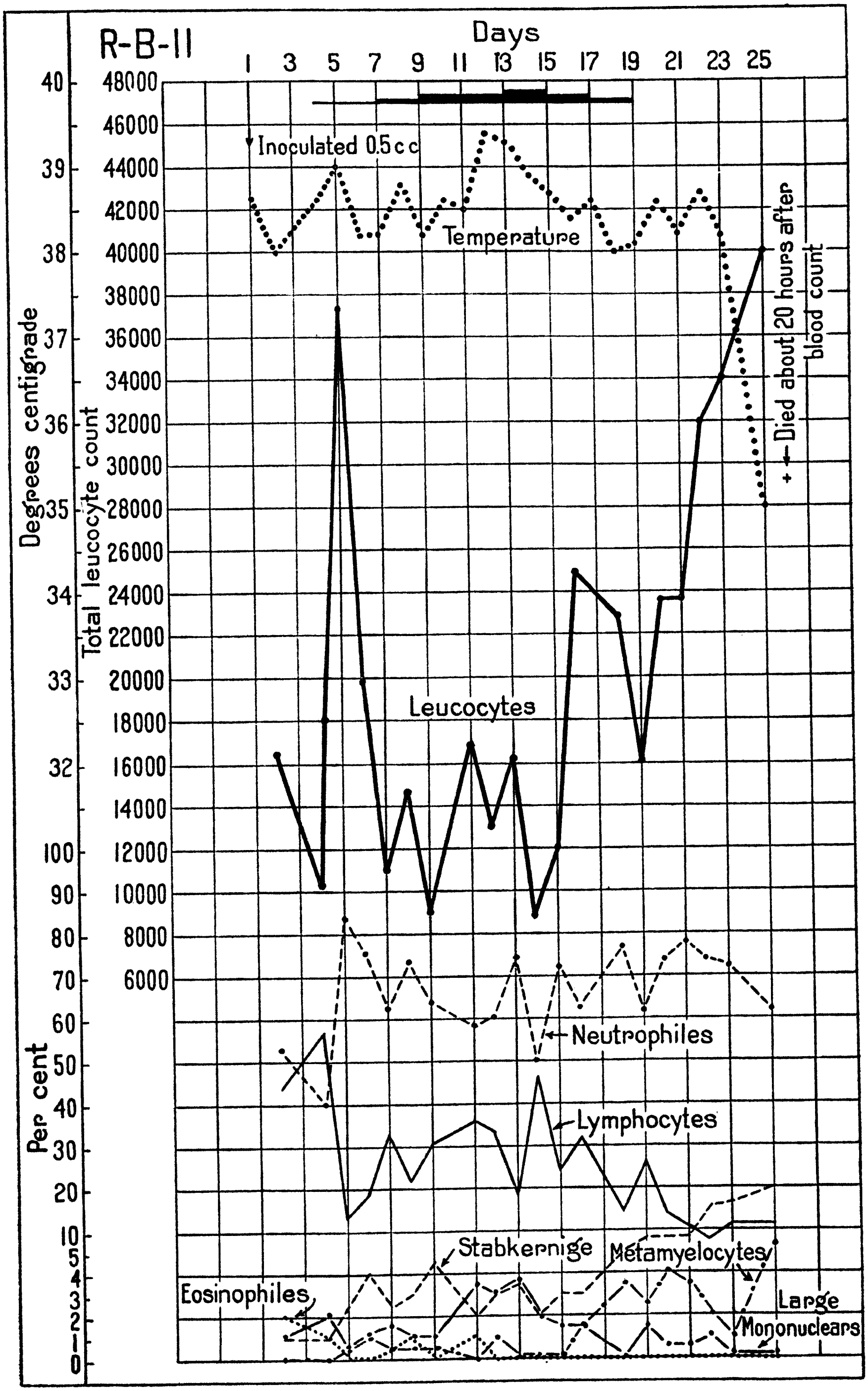


PLATE 8. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-11.

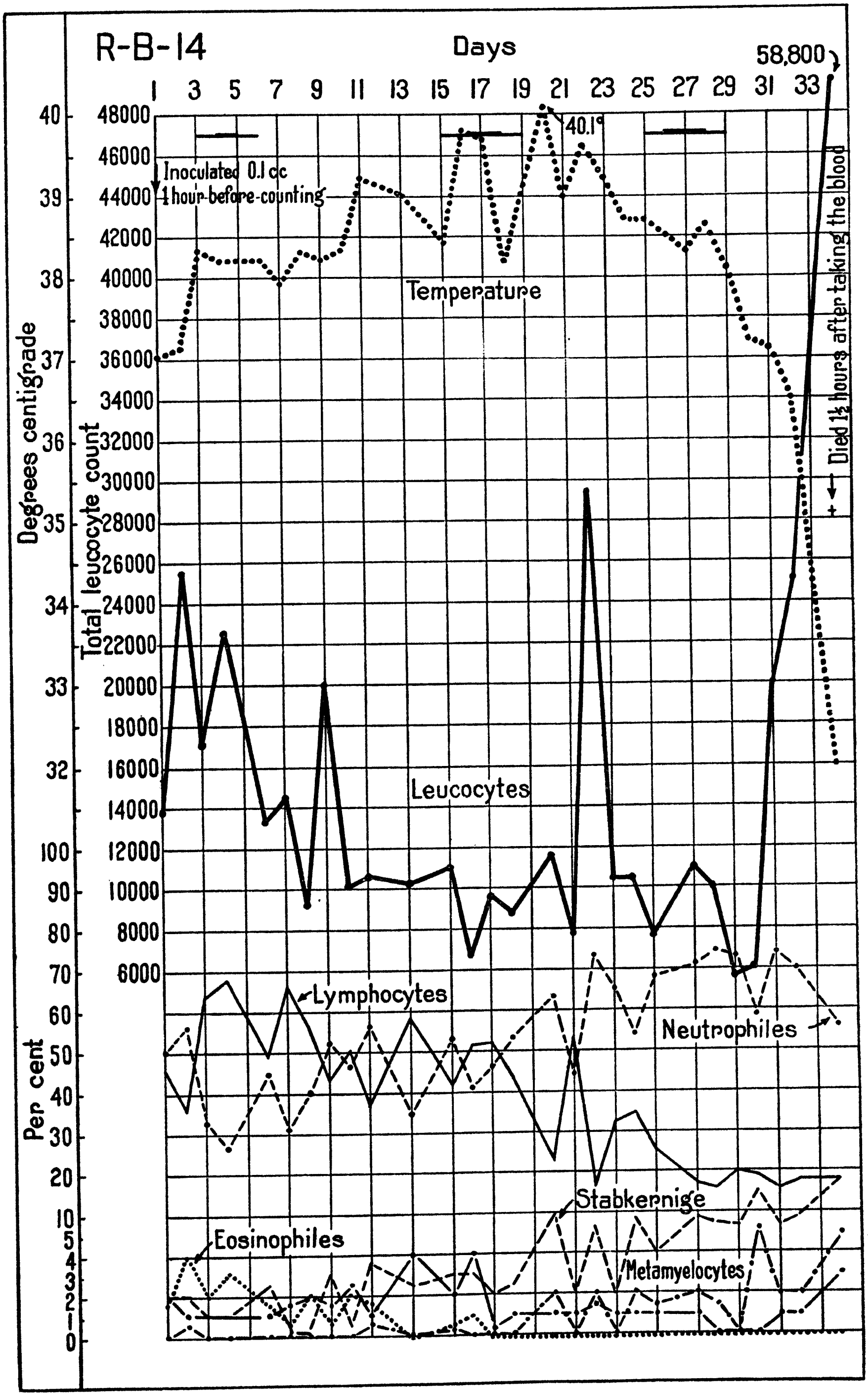


PLATE 9. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-14

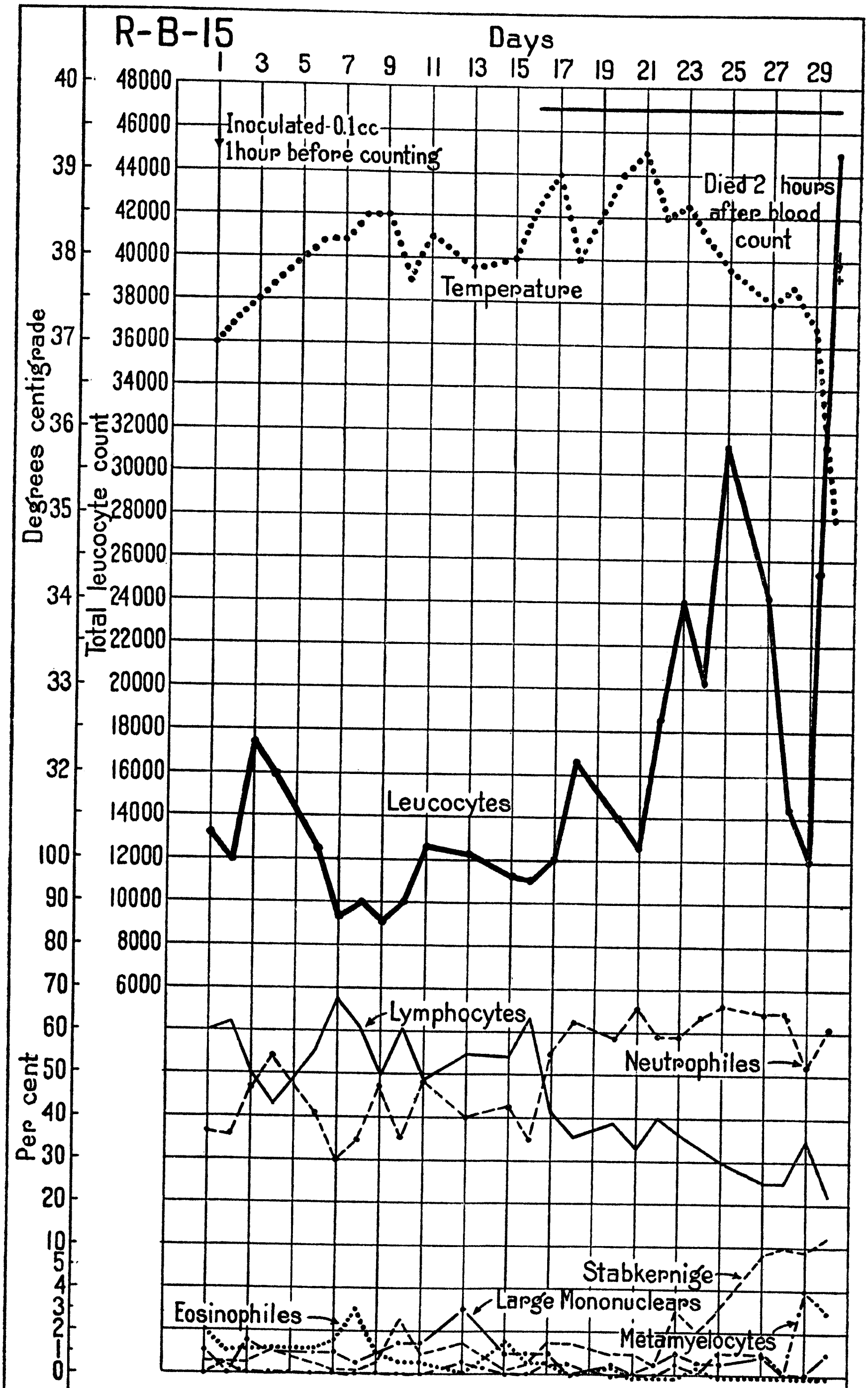


PLATE 10. TEMPERATURE CURVE AND BLOOD PICTURE OF R-B-15.

SOLAR ULTRAVIOLET RADIOMETRY *

III, COMPARATIVE VALUES FOR MANILA AND BAGUIO PHILIPPINE ISLANDS

By Wm. D. Fleming

Major, Medical Corps, United States Army; Member, United States Army Medical Department Research Board, Bureau of Science, Manila

This article reports the solar energy in four spectral regions, 290 to 310, 310 to 370, 370 to 400, and 400 to 460 millimicrons, and the total solar energy up to 1,400 millimicrons found at two localities in the Philippine Islands during adjacent months.

The instruments and procedures used were those described in the second article of this series.(1) The values for Manila were obtained from October 31, 1931, to December 23, 1931, for the most part in December, 1931. Baguio values were obtained during January, 1932.

Manila, Philippine Islands, lies on the east shore of Manila Bay on the west coast of Luzon Island. The population is about 350,000. The majority of the streets are unpaved and the combination of horse-drawn and automobile traffic is productive of much dust in the dry weather.

For the Manila observations, the instruments were placed on the roof of San Jose College in which the Philippine Weather Bureau is located. This lies 14° 35′ north latitude and 120° 59′ east longitude. The roof is over the third story of the building and affords a clear view of all quarters of the sky.

The months of November and December in Manila are included in the cool season. The mean temperature for November was 25.9° C. (78° F.), for December 24.9° C. (77° F.).

Baguio, Philippine Islands, lies about 160 miles north of Manila, in the Mountain Province. Camp John Hay, at which the observations were made, lies on the outskirts of the city

* Submitted for publication August 11, 1932.

at an elevation of 4,800 feet above sea level and at 16° 24′ north latitude and 120° 37′ east longitude. There is very little traffic through the post and most of this is on paved roads. For the month of January, 1932, the temperature ranged during the day from 63° F. to 75° F.

The instruments for the Baguio observations were placed on the roof of the west wing of the dormitory at Camp John Hay. This was one story above the ground. A clear view was had of all quarters, except on the west where a high ridge about one hundred yards away cut off the sun at about 4.30 in the afternoon.

The means of values obtained throughout the periods reported are given in Tables 1 to 5. These tables give (*a*) morning sun values, (*b*) afternoon sun values, (*c*) values for the day as a whole; that is, values for air mass 1.3 for morning are grouped with values for afternoon air mass 1.3. Values are tabulated according to air mass rather than time of day and are given both in percentages of the total energy present between λ 290 and 1,400 millimicrons and in microwatts per square millimeter of surface. Under the heading "AD" is given the deviation of the mean for the value immediately above. This is shown to give some indication of how much variation there was in the light. Under the heading "Ratio $\frac{B}{M}$" is given the ratio of the values obtained in Baguio to the corresponding finding in Manila.

DISCUSSION

The present study is limited to a comparison between the sunlight of the two places at as nearly the same time as possible; namely, adjacent months. No attempt will be made, therefore, to discuss variations of the light as a function of the time of year. The two periods fall roughly equally on either side of the winter solstice, and the weather was stable in both places.

COMPARATIVE ENERGY VALUES

Only a few published values for solar ultraviolet energy are available in the Philippines. Forsythe and Christison(2) have published calculated values for solar energy below λ 310 millimicrons. Reduced to the units used in this work, microwatts

per square millimeter, they give the following for various air masses at Cleveland, Ohio:

Air mass	1.0	1.07	1.5	2.37
Microwatts per square millimeter	0.29	0.20	0.061	0.0041

Coblentz, on the other hand, using a filter method somewhat similar to that of the present work, finds much higher values for this same region below λ 310 millimicrons. For an air mass of 1.09 in Washington, D. C., in June, he(3) found 0.90 microwatts per square millimeter. For the same place in November and December for air masses of about 2.4, his values are(4) from 0.08 to 0.22 microwatts per square millimeter; and in February, for air mass 1.75 he found 0.33 microwatts per square millimeter. At a higher altitude at Flagstaff, Arizona, 7,250 feet elevation, in September, he found about 0.75 microwatts per square millimeter for air masses about 1.20. These values are of the same order of magnitude as those reported in the present work.

As far as either the Washington figures of Coblentz or the Manila figures go, no evidence appears of an excessive amount of ultraviolet below 310 millimicrons in Manila. No closer comparison will be attempted at the present time.

RELATIVE VALUES FOR MANILA AND BAGUIO

This relation is shown under the heading "Ratio $\frac{B}{M}$" in Tables 1 to 5. From this ratio in Tables 1, 2, and 3, it is apparent that the three ultraviolet components constituted a greater portion of the total sunlight in Baguio than in Manila. This difference is especially marked in the extreme ultraviolet.

In the case of the band on the limit of the visible λ 400 to 460 millimicrons, Table 4 shows that both places possessed about equal percentages.

Table 5 shows that the total amount of energy was uniformly higher in Baguio. This has the effect of still further increasing the $\frac{B}{M}$ ratio for the actual energy present in the three ultraviolet bands. The finding of a greater amount of sunlight energy in Baguio was, of course, to be expected on account of the elevation of the place.

TABLE 1.—*290 to 310 millimicrons.*

A. MORNING SUN.

	Air mass. 1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	0.058	0.074	0.064	0.056	0.061	0.052	0.061	0.035	0.040	0.030	0.053
AD ±	0.005	0.003	0.004	0.004	0.005	0.005	0.005	----	0.002	0.002	0.004
Manila	0.034	0.029	0.023	0.017	0.018	0.021	0.027	0.021	0.010	0.004	0.020
AD ±	0.008	0.005	0.007	0.006	0.005	0.008	----	0.008	0.003	0.002	0.006
Ratio $\frac{B}{M}$	1.7	2.6	2.8	3.2	3.4	2.5	2.3	1.7	4.0	7.5	2.6
	Microwatts per square millimeter.										
Baguio	0.60	0.78	0.65	0.56	0.59	0.53	0.58	0.35	0.39	0.27	0.53
AD ±	0.05	0.03	0.03	0.04	0.06	0.15	0.05	----	0.03	0.02	0.05
Manila	0.28	0.30	0.27	0.13	0.13	0.08	0.21	0.10	0.06	0.03	0.16
AD ±	0.07	0.07	0.05	0.07	0.04	0.03	----	0.09	0.02	0.02	0.05
Ratio $\frac{B}{M}$	2.1	2.6	2.4	4.3	5.0	6.7	2.8	3.5	6.5	9.0	3.3

B. AFTERNOON SUN.

	Air mass. 1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	0.059	0.076	0.069	0.066	0.063	0.061	0.055	0.006	0.051	0.030	0.018	----	0.056
AD ±	0.003	0.005	0.004	0.006	0.012	0.007	0.012	----	0.005	0.002	0.003	----	0.004
Manila	0.045	0.015	0.045	0.032	----	0.036	----	----	0.010	0.009	0.015	0.004	0.023
AD ±	----	0.001	0.019	0.007	----	0.015	----	----	0.005	0.004	0.004	0.002	0.008
Ratio $\frac{B}{M}$	1.3	7.6	1.7	2.0	----	1.7	----	----	5.1	3.3	1.2	----	2.2

	Microwatts per square millimeter.												
Baguio	0.61	0.76	0.67	0.65	0.61	0.58	0.52		0.41	0.24	0.11		0.52
AD ±	0.06	0.06	0.05	0.06	0.11	0.07	0.11		0.05	0.03	0.02		0.06
Manila	0.38	0.09	0.28	0.24		0.45		0.43	0.06	0.08	0.10	0.02	0.22
AD ±		0.06	0.22	0.07		0.13			0.03	0.03	0.02	0.01	0.06
Ratio $\frac{B}{M}$	1.6	8.4	2.4	2.7		1.3			6.9	3.0	1.1		2.4

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	0.058	0.074	0.066	0.059	0.062	0.055	0.058		0.044	0.030	0.056
AD ±	0.003	0.003	0.004	0.004	0.005	0.004	0.006		0.003	0.002	0.004
Manila	0.036	0.027	0.029	0.025		0.027		0.031	0.010	0.008	0.024
AD ±	0.007	0.006	0.007	0.005		0.007		0.010	0.003	0.003	0.006
Ratio $\frac{B}{M}$	1.7	2.7	2.3	2.4		2.0			4.4	3.8	2.3
	Microwatts per square millimeter.										
Baguio	0.61	0.78	0.66	0.58	0.60	0.54	0.55		0.39	0.26	0.55
AD ±	0.04	0.03	0.03	0.04	0.05	0.04	0.05		0.03	0.02	0.04
Manila	0.29	0.28	0.27	0.20		0.26		0.19	0.06	0.07	0.20
AD ±	0.06	0.07	0.06	0.05		0.09		0.08	0.02	0.02	0.06
Ratio $\frac{B}{M}$	2.1	2.8	2.3	2.9		2.0			6.9	3.7	2.7

TABLE 2.—*310 to 370 millimicrons.*

A. MORNING SUN.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	2.0	1.8	1.7	1.7	1.6	1.5	1.4	0.015	1.2	0.8	1.5
AD ±	0.0	0.2	0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.1
Manila	1.8	1.4	1.4	1.5	1.3	1.2	1.5	1.1	0.8	0.4	1.2
AD ±	0.1	0.1	0.1	0.1	0.1	0.1		0.1	0.1	0.2	0.1
Ratio $\frac{B}{M}$	1.2	1.3	1.2	1.1	1.2	1.3	0.9	1.4	1.5	2.0	1.3
	Microwatts per square millimeter.										
Baguio	20.9	18.5	17.6	16.5	15.5	15.1	12.9	14.2	11.0	7.4	15.0
AD ±	0.1	0.2	0.4	0.5	0.9	0.3	0.5		0.3	0.2	0.4
Manila	15.7	14.1	11.4	13.3	9.8	7.4	11.8	6.8	5.7	1.7	9.8
AD ±	0.7	0.5	0.7	1.7	1.1	2.5		2.1	0.3	0.0	1.0
Ratio $\frac{B}{M}$	1.3	1.3	1.5	1.4	1.6	2.0	1.1	2.1	1.9	4.3	1.5

B. AFTERNOON SUN.

	Air mass.												
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	1.9	1.9	1.7	1.5	1.6	1.4	1.3		1.1	0.8	0.5		1.4
AD ±	0.0	0.1	0.1	0.1	0.1	0.0	0.1		0.1	0.1	0.1		0.1
Manila	1.7	1.7	1.5	1.6		1.3		0.8	1.0	0.5	0.4	0.1	1.2
AD ±	0.0	0.1	0.1	0.2		0.1			0.1	0.1	0.1	0.1	0.1
Ratio $\frac{B}{M}$	1.1	1.1	1.1	0.9		1.1			1.1	1.6	1.8		1.2

	Microwatts per square millimeter.										
Baguio	19.7	17.2	16.9	15.1	15.5	13.1	----	----	9.9	6.5	8.9	----	13.6
AD ±	0.1	0.2	0.4	0.3	0.5	0.4	----	----	0.3	0.4	0.3	----	0.3
Manila	13.6	13.1	10.9	11.1	----	9.8	----	6.1	6.6	3.2	2.4	0.3	8.5
AD ±	0.0	3.0	1.0	0.9	----	0.8	----	----	0.8	0.4	0.2	0.2	0.8
Ratio $\frac{B}{M}$	1.5	1.3	1.6	1.5	----	1.3	----	----	1.5	2.0	3.7	----	1.6

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	2.0	1.8	1.7	1.6	1.6	1.5	1.4	----	1.2	0.8	1.5
AD ±	0.2	0.1	0.1	0.1	0.1	0.3	0.1	----	0.1	0.1	0.1
Manila	1.7	1.6	1.4	1.6	----	1.3	----	1.0	0.9	0.4	1.3
AD ±	0.1	0.1	0.1	0.1	----	0.1	----	0.1	0.1	0.1	0.1
Ratio $\frac{B}{M}$	1.2	1.1	1.2	1.0	----	1.2	----	----	1.3	2.0	1.2
	Microwatts per square millimeter.										
Baguio	20.4	18.2	17.3	16.1	15.7	14.6	12.7	----	10.6	7.1	14.7
AD ±	0.3	0.3	0.3	0.4	0.5	0.3	0.3	----	0.2	0.2	0.3
Manila	15.5	13.1	11.2	12.0	----	8.6	----	6.7	6.0	2.9	9.5
AD ±	0.7	0.5	0.6	0.9	----	1.1	----	1.6	0.3	0.4	0.8
Ratio $\frac{B}{M}$	2.1	1.4	1.6	1.3	----	1.7	----	----	1.8	2.4	1.6

TABLE 3.—*370 to 400 millimicrons.*

A. MORNING SUN.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	3.2	3.1	3.0	2.9	2.8	2.5	2.7	2.5	2.3	2.1	2.7
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	----	0.1	0.1	0.1
Manila	2.7	2.7	2.8	2.5	2.7	2.1	2.4	2.1	2.5	1.9	2.4
AD ±	0.2	0.1	0.1	0.1	0.2	0.4	----	0.0	0.1	0.1	0.1
Ratio $\frac{B}{M}$	1.2	1.1	1.1	1.2	1.0	1.2	1.1	1.2	0.9	1.1	1.1
	Microwatts per square millimeter.										
Baguio	32.2	32.0	31.0	29.9	27.1	26.1	25.3	25.8	22.6	18.1	27.0
AD ±	0.9	0.3	0.5	0.5	1.0	1.0	0.8	----	0.4	0.5	0.6
Manila	23.4	24.1	22.5	23.0	19.9	23.2	19.0	12.3	18.0	9.1	19.5
AD ±	1.1	0.8	0.9	1.4	0.8	2.2	----	3.2	0.2	1.3	1.2
Ratio $\frac{B}{M}$	1.4	1.3	1.4	1.3	1.4	1.1	1.3	2.1	1.2	2.0	1.4

B. AFTERNOON SUN.

	Air mass.												
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	3.3	2.9	3.1	2.9	2.9	2.9	2.4	----	2.5	2.2	1.0	----	2.6
AD ±	0.1	0.1	0.1	0.1	0.0	0.1	0.0	----	0.1	0.2	0.2	----	0.1
Manila	2.8	2.3	2.9	2.5	----	2.2	----	1.7	1.8	1.5	0.8	0.5	2.0
AD ±	0.0	0.4	0.1	0.1	----	0.1	----	----	0.1	0.1	0.1	0.1	0.1
Ratio $\frac{B}{M}$	1.2	1.2	1.1	1.2	----	1.5	----	----	1.4	1.5	0.9	----	1.3

	Microwatts per square millimeter.												
Baguio	34.4	31.2	31.6	28.4	28.1	26.7	23.2	----------	21.5	16.1	8.9	----------	25.0
AD ±	0.2	1.0	0.5	0.5	0.3	0.2	0.1	----------	0.8	0.7	0.3	----------	0.5
Manila	24.4	21.0	23.3	18.4	----------	16.3	----------	12.1	11.4	8.6	5.0	1.4	15.6
AD ±	0.0	2.5	3.0	1.9	----------	1.0	----------	----------	1.1	1.2	0.7	0.5	1.2
Ratio $\frac{B}{M}$	1.4	1.5	1.4	1.5	----------	2.4	----------	----------	1.9	1.9	1.9	----------	1.6

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	3.2	3.0	3.1	2.9	2.8	2.6	2.5	----------	2.4	2.2	2.7
AD ±	0.1	0.1	0.1	0.1	0.1	0.1	0.1	----------	0.1	0.1	0.1
Manila	2.7	2.8	2.8	2.5	----------	2.1	----------	2.0	2.2	1.4	2.3
AD ±	0.1	0.1	0.1	0.1	----------	0.2	----------	0.1	0.1	0.1	0.1
Ratio $\frac{B}{M}$	1.2	1.1	1.1	1.2	----------	1.2	----------	----------	1.1	1.6	1.2
	Microwatts per square millimeter.										
Baguio	33.1	31.8	31.2	29.5	27.5	26.3	24.4	----------	22.2	17.3	27.0
AD ±	0.5	0.3	0.4	0.4	0.5	0.7	0.5	----------	0.3	0.4	0.4
Manila	23.5	22.2	22.7	20.3	----------	20.2	----------	12.3	15.6	8.7	18.2
AD ±	0.9	0.9	1.0	1.3	----------	1.6	----------	2.1	1.0	1.0	1.2
Ratio $\frac{B}{M}$	1.0	1.4	1.4	1.5	----------	1.3	----------	----------	1.4	2.0	1.5

TABLE 4.—*400–460 millimicrons.*

A. MORNING SUN.

	Air mass. 1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	9.5	8.9	8.8	8.5	8.6	8.8	8.5	9.3	8.0	7.2	8.6
AD ±	0.1	0.1	0.1	0.1	0.1	0.2	0.2		0.1	0.1	0.1
Manila	9.9	9.9	9.1	10.5	8.4	10.2	8.2	9.0	8.9	6.2	9.0
AD ±	2.2	0.2	0.2	0.5	0.5	1.4		0.1	0.2	0.1	0.6
Ratio $\frac{B}{M}$	1.0	0.9	1.0	0.8	1.0	0.9	1.0	1.0	0.9	1.2	1.0
	Microwatts per square millimeter.										
Baguio	99.0	89.0	90.0	85.0	84.0	88.0	78.0	92.0	78.0	69.0	85.0
AD ±	2.0	1.0	2.0	1.0	3.0	1.0	2.0		1.0	1.0	2.0
Manila	84.0	80.0	73.0	87.0	65.0	73.0	65.0	52.0	64.0	30.0	67.0
AD ±	3.1	2.1	3.2	4.6	5.0	5.6		13.0	2.0	3.6	5.0
Ratio $\frac{B}{M}$	1.2	1.1	1.2	1.0	1.3	1.2	1.2	1.8	1.2	2.3	1.3

B. AFTERNOON SUN.

	Air mass. 1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	9.1	8.7	8.5	8.6	8.6	8.7	8.4		8.1	6.8	5.5		8.1
AD ±	0.01	0.3	0.1	0.2	0.3	0.4	0.2		0.1	0.2	0.3		0.3
Manila	10.9	7.2	9.3	10.6		8.9		10.5	9.0	7.1	6.2	3.5	8.8
AD ±	0.0	1.8	0.5	0.2		2.0			0.7	0.2	0.3	0.4	0.7
Ratio $\frac{B}{M}$	0.8	1.2	0.9	0.8		1.0			0.9	1.0	0.9		0.9

	Microwatts per square millimeter.												
Baguio	94.0	86.0	85.0	85.0	84.0	82.0	79.0	----	72.0	59.0	36.0	----	76.0
AD ±	4.0	3.0	1.0	2.0	4.0	2.0	2.0	----	2.0	2.0	2.0	----	2.0
Manila	96.0	78.0	72.0	75.0	----	77.0	----	69.0	55.0	41.0	34.0	12.1	66.0
AD ±	0.0	6.0	9.0	6.0	----	12.0	----	----	3.0	4.0	2.0	3.0	5.0
Ratio $\frac{B}{M}$	1.0	1.1	1.2	1.1	----	1.1	----	----	1.3	1.4	1.1	----	1.2

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Baguio	9.3	8.8	8.7	8.5	8.6	8.5	8.4	----	8.1	7.1	8.4
AD ±	0.1	0.1	0.1	0.1	0.1	0.2	0.1	----	0.1	0.1	0.2
Manila	10.0	9.4	9.2	10.5	----	10.6	8.2	9.4	8.9	6.9	9.2
AD ±	0.2	0.2	0.2	0.2	----	1.2	----	0.4	0.3	0.2	0.4
Ratio $\frac{B}{M}$	0.9	0.9	0.9	0.8	----	0.8	----	----	0.9	1.0	0.9
	Microwatts per square millimeter.										
Baguio	97.0	89.0	88.0	85.0	84.0	87.0	79.0	----	76.0	65.0	83.0
AD ±	2.0	1.0	1.0	1.0	3.0	1.0	2.0	----	1.0	1.0	1.0
Manila	88.0	75.0	73.0	80.0	----	75.0	65.0	56.0	61.0	38.0	68.0
AD ±	3.0	2.2	3.2	3.9	----	6.0	----	10.0	1.0	4.0	4.0
Ratio $\frac{B}{M}$	1.1	1.2	1.2	1.1	----	1.2	----	----	1.2	1.7	1.2

TABLE 5.—*290 to 1,400 millimicrons.*

A. MORNING SUN.

	Air mass. 1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	Microwatts per square millimeter.										
Baguio	1,042	1,040	1,023	1,003	981	1,021	944	995	960	914	992
AD ±	5	4	10	20	29	7	19	------	8	9	12
Manila	841	832	802	868	767	845	793	577	729	490	754
AD ±	17	13	16	14	24	37	------	204	6	61	44
Ratio $\frac{B}{M}$	1.2	1.3	1.3	1.2	1.3	1.2	1.2	1.2	1.7	1.9	1.3

B. AFTERNOON SUN.

	Air mass. 1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	5.0	Mean.
	Microwatts per square millimeter.												
Baguio	1,040	999	1,013	995	974	943	952	------	900	811	685	------	931
AD ±	18	12	4	30	8	16	12	------	11	11	28	------	15
Manila	873	764	774	713	------	733	------	714	639	555	559	314	703
AD ±	0	49	80	66	------	49	------	------	38	43	22	45	44
Ratio $\frac{B}{M}$	1.2	1.3	1.3	1.4	------	1.3	------	------	1.4	1.5	1.2	------	1.3

C. TOTAL DAY.

	Air mass.										
	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	Mean.
	Microwatts per square millimeter.										
Baguio	1,041	1,032	1,019	1,001	978	992	950		943	873	981
AD ±	6	4	6	13	17	11	12		9	12	10
Manila	845	824	795	775		789	793	611	697	539	741
AD ±	15	13	19	38		30		104	15	16	31
Ratio $\frac{B}{M}$	1.2	1.3	1.3	1.3		1.3			1.4	1.6	1.3

Freer and Gibbs(5) reported a comparison of Manila and Baguio sunlight in 1912. They used the uranyl-oxalic acid method, which was discussed in the first paper of this series.(1) The reaction is activated most strongly by light of about λ 310 millimicrons, though it is affected by all of the solar ultraviolet. For the months of March, April, May, and June, 1911, in Baguio they found a mean of 14.2 per cent of oxalic acid decomposed per hour, while in Manila a mean of 13.6 per hour was decomposed for the same months. This gives a ratio $\frac{B}{M} = 1.05$. Taking the mean of results in Manila from May, 1910, to July, 1911, as 12.5 per cent, the $\frac{B}{M}$ ratio of 1.14 was obtained. The values in Baguio were probably decreased by the low figure for July due, presumably, to cloudy weather. Further, the values represent a wider spectral region than any one of the three ultraviolet regions reported in the present work, probably representing nearly the sum of all three regions. However, after allowance is made for all these considerations, the ratio $\frac{B}{M}$ appears much lower than those now reported.

VARIABILITY OF LIGHT

Under the heading "AD" the tables give the deviation of the mean of the tabulated values.

$$AD = \frac{a.d.}{\sqrt{n}} \text{ where } a.d. = \frac{\sum d}{n} \text{ and}$$

$d =$ difference between individual value and the mean
$n =$ number of observations.

Using this quantity AD as an indication of the variability of the light it is seen from the tables that the light in Manila was much more variable than in Baguio. This is particularly marked in the values for total energy.

RATIO OF MORNING LIGHT TO AFTERNOON LIGHT

There is a common belief in Manila that the morning light is much stronger than that of the afternoon, especially in its burning effects. Persons swimming or playing tennis or golf in the afternoon on week days without sunburn are apt to report sunburn after a Sunday morning exposure. To examine this the ratios of morning sun to afternoon sun have been compiled in Table 6. In this are given the means of the ratio

morning sun to afternoon sun obtained for all the different air masses studied. These means are grouped in three different ways, as follows:

(a) The mean of values for all air masses 1.2 to 3.
(b) The mean of values for air masses 1.2 to 1.5, inclusive. This included for Manila from about 9.30 a. m. to 12 noon and 12 noon to about 2 p. m., for Baguio from 10 a. m. to 12 noon and from 12 noon to about 2 p. m.
(c) The mean of values for air masses 1.6 to 3, inclusive. This included morning hours before and afternoon hours after those of (b).

TABLE 6.—*Mean values of the ratio Morning sun to Afternoon sun.*

Millimicrons.	Air mass. Manila.					
	1.2-3.0	1.2-1.5	1.6-3.0	1.2-3.0	1.2-1.5	1.6-3.0
	Per cent.	*Per cent.*	*Per cent.*	*Microwatts.*	*Microwatts.*	*Microwatts.*
290-310	0.82	0.94	0.67	1.01	1.39	0.52
310-370	0.90	0.94	0.84	0.95	1.12	0.72
370-400	1.12	1.03	1.22	1.19	1.08	1.29
400-460	1.02	1.07	0.93	0.97	1.04	0.90
290-1,400	----------	----------	--------	1.04	1.08	1.00

Millimicrons.	Air mass. Baguio.					
	1.2-3.0	1.2-1.5	1.6-3.0	1.2-3.0	1.2-1.5	1.6-3.0
	Per cent.	*Per cent.*	*Per cent.*	*Microwatts.*	*Microwatts.*	*Microwatts.*
290-310	0.92	0.90	0.94	0.98	0.92	1.02
310-370	1.04	1.04	1.03	1.08	1.07	1.10
370-400	0.98	1.00	1.21	1.02	1.00	1.04
400-460	1.02	1.02	1.01	1.05	1.04	1.06
290-1,400	----------	----------	----------	1.04	1.01	1.05

For the total energy (290 to 1400 millimicrons) at both Manila and Baguio, the differences between morning and afternoon sun are very small and insignificant. In the case of Baguio this same relation holds for all four of the spectral fractions investigated.

In Manila, however, two instances of marked difference between morning and afternoon light appear. For air mass 1.2 to 1.5 (that is, from about 10 a. m. to noon and from noon to

about 2 p. m.) the morning light in actual energy present exceeds the afternoon light in the ratio of 1.39 for the band λ 290 to 310 millimicrons and in the ratio of 1.12 for the band λ 310 to 370 millimicrons. Since the production of erythema is due largely to light of wavelength peaked narrowly about λ 310 millimicrons, this should explain the more-marked burning effect of the morning sun.

This apparent difference is probably enhanced by the hours of customary sun exposure as governed by living conditions in Manila. Recreation on Sunday morning is apt to be taken between 10 o'clock and noon rather than earlier. On the other hand, afternoon sports usually occur after the siesta or office hours, after 3 o'clock, if not later. The popular impression, therefore, is due partly to the morning exposure being to sunlight through an air mass less than 1.5, while the afternoon exposure is to sun through an air mass exceeding 1.5. Nevertheless, there does appear to be a greater amount of energy capable of causing erythema in the morning light.

The only explanation of this that can be offered at present is the greater opacity of the lower atmosphere in the afternoon due to traffic in the city beating up a dust cloud with possibly sufficient carbon monoxide from automobile engines to aid in a selective absorption. The dust settles during the night, and the carbon monoxide, if a factor, is dissipated. Morning traffic in Manila is fairly evenly diffused but rises to a sharp peak at 12 noon when cars running at high speed fill the streets with office workers going to lunch.

Against this explanation must be cited the statements of several persons living on Corregidor Island, in the mouth of Manila Bay, 30 miles west of the City of Manila. These persons have observed the same greater burning power of the morning sun on Corregidor and even on small boats sailing short distances west of Corregidor. This is certainly too far west of Manila to be affected by any dust due to city traffic, although here again the possibility of the hours of morning exposure being at times of air mass less than 1.5 and afternoon exposure at times of air mass greater than 1.5 must be remembered. It is planned to make a series of observations on Corregidor to see if this difference appears in values obtained instrumentally.

Earp,(6) in comparing values obtained at Boulder, Colorado, with those obtained at Baltimore, Maryland, both by the zinc

sulphide method, says, "In Baltimore there is a tendency for higher readings in the afternoon. In Boulder the typical curve appears to be that for June 30th with a maximum about 11 a. m. and a plateau of high readings in the early afternoon." The Baltimore values mentioned are apparently those obtained by Clark.(7) Neither Earp nor Clark discusses this feature further.

SUMMARY

1. No evidence of an excessive amount of ultraviolet light in Manila in December as compared with Washington, D. C., was found.
2. The amount of energy in three spectral regions in the ultraviolet was much greater in Baguio than in Manila, Philippine Islands. Light in the visible violet region was about equal for the two places. The total energy present in the sunlight was greater in Baguio than in Manila.
3. Greater variations were present in the sunlight in Manila than in Baguio.
4. Some evidence was found that morning sunlight in Manila possessed greater erythema-producing energy than the afternoon sunlight. Dust raised by city traffic is discussed as an explanation of this.

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ABSTRACT

Solar energy values for three spectral regions in the ultraviolet and one region in the violet limit of visible light are reported from the Philippine Islands, for Manila, at sea level, and for Baguio, at 4,800 feet elevation.

CHIRONOMIDÆ FROM JAPAN (DIPTERA)
I. CLUNIONINÆ [1]

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TWO PLATES

The chironomid flies discussed in this paper are entirely from the seashores of Japan, where they were collected by Prof. Dr. Hachiro Yuasa, Prof. Dr. Teizo Esaki, and by myself. I am greatly indebted to Professor Yuasa for his kind directions which made this study possible. My deepest thanks are also extended to Professor Esaki for the privilege of retaining the types of rare forms described in the following pages.

The subfamily Clunioninæ contains, at present, seven genera; namely, *Clunio* Haliday, *Eretmoptera* Kellogg, *Halirytus* Eaton, *Paraclunio* Kieffer, *Psammathiomyia* Deby, *Telmatogeton* Schiner, and *Thalassomyia* Schiner. Only two of these genera, *Clunio* and *Telmatogeton*, which are dealt with in this paper, are known from Japan, as far as I can ascertain, although it is more than probable that other genera will be found when more thorough collecting is undertaken. In the present report four marine chiromonid flies, two species and one variety of *Clunio* and one species of *Telmatogeton*, are discussed as new to science.

From the ecological point of view, *Telmatogeton* is the most interesting. Some of the flies of this genus were found in torrents of the Hawaiian Islands, and the others were found on the coasts of oceans in various parts of the world, while all the other genera of the Clunioninæ are truly marine in habitat. The Japanese flies of the genus *Telmatogeton* are also found right on the coast of the Pacific Ocean, but the curious fact is that flies of the same species found on the coast of the Japan Sea establish their colonies only on the inner side of the breakwater at the estuary. The specimens collected at the latter locality were reared to the imago stage from the larvæ en-

[1] Contribution from the entomological laboratory, Kyoto Imperial University, No. 28.

tirely in fresh water. This is an interesting fact that suggests the divergent habitats of this genus. Another interesting point is the morphological feature of the tarsal claws and their accessory structures. The ultimate tarsal joints of the two sexes of *Telmatogeton* are provided each with a pair of thin lamellæ in place of the pulvilli, and those of the male of *Clunio* each with a pair of claws which are provided with a large thin lamella on each ventral side. These modifications might have been derived from different original structures; those of *Telmatogeton* are probably homologous with the pulvilli and those of *Clunio* are probably identical with the hairs on the claw similar to those of *Pontomyia* discussed in my paper of 1932.

A certain marine chironomid fly reported as a *Paraclunio* species in my previous papers on marine insects in 1930 and 1932 is now determined as a new species of *Telmatogeton,* as will be described later.

Abbreviations used in this paper are as follows: A.R. is the antennal ratio in length between the ultimate joint and the remaining joints of the flagellum and the pedicel taken together. fCu is the cubital fork of the wing vein between M_{3+4} and Cu_1. Terminology of the wing venation used is that of the Comstock-Needham-Tillyard system and that of the head, thorax, and hypopygium used is that of the MacGillivray system modified by Tokunaga.

Key to the genera of Clunioninæ.

1. Wings normal, at least in the male.................... 2.
   Wings not normal, reduced in both sexes.................... 5.
2. Squamæ of the wings bare.................... *Clunio* Haliday.
   Squamæ of the wings fringed.................... 3.
3. Maxillary palpi segmented .... 4.
   Maxillary palpi unsegmented.................... *Paraclunio* Kieffer.
4. Maxillary palpi 2-segmented.................... *Telmatogeton* Schiner.
   Maxillary palpi 4-segmented .... *Thalassomyia* Schiner.
5. Antennæ 7-segmented .... *Psammathiomyia* Deby.
   Antennæ with less than seven segments.................... 6.
6. Fifth tarsal segment trilobated at tip.................... *Halirytus* Eaton.
   Fifth tarsal segment simple at tip.................... *Eretmoptera* Kellogg.

Genus CLUNIO Haliday

Key to species of Clunio Haliday.

MALES

1. Ultimate joint of the antenna shorter than the preceding seven joints taken together .... 2.
   Ultimate joint of the antenna longer than or subequal to the preceding seven joints taken together.................... 4.

2. Cu_1 slightly curved .... *C. setoensis* sp. nov.
   Cu_1 distinctly curved, recurvate.. 3.
3. R_{4+5} shorter than twice the proximal section of M.
   C. marinus Haliday = *bicolor* Kieffer.
   R_{4+5} longer than or subequal to twice the proximal section of M.
   C. adriaticus Schiner = *balearicus* Bezzi.
4. Cu_1 distinctly curved .... 5.
   Cu_1 slightly curved .... *C. pacificus* Edwards.
5. Ultimate joint of the antenna shorter than one-half the entire length.
   C. tsushimensis sp. nov.
   Ultimate joint of the antenna subequal to or longer than one-half the entire length .... *C. tsushimensis* var. *minor* var. nov.

CLUNIO SETOENSIS sp. nov.

This fly was found among the algal matting of the rocky seashore between the tide marks of the Pacific coast at Seto. A male pupa and a male pupal skin were also collected at the same place, but the larval forms and the adult females have not been obtained.

Male.—Body about 2.1 mm in length, very scantily haired; general coloration greenish; wings milky white; head, thorax, and abdominal tip brown; legs generally pale greenish brown; scutellum pale green, with many brown setæ; mid-dorsal suture black, without setæ; pseudosutural foveæ each with several small setæ along it; supra-alar setal group represented by two small setæ.

Head round and small. Eyes oval, covered with velutinous hairs; distance between eyes less than their vertical length, this ratio being 10 : 17. Clypeus without setæ. Maxillary palpi not segmented, fingerlike, brown on the distal half, each with a few small setæ on its tip. Mouth parts greatly reduced; paraglossæ atrophied. Antennæ (Plate 1, fig. 4) without plumose setæ, 10-segmented (excepting the antennariæ); antennaria triangular in the frontal aspect, brown; scape also brown, bulbous, longer than broad, with several hyaline sensory hairs, distinctly narrowed on its proximal end; second joint pale green, brown on its distal margin, quite long, subequal in length to the following four joints taken together, with two small brown setæ on its middle part; ultimate joint somewhat spindle-shaped, distinctly narrowed on the distal part, greenish white under reflected light and pale brown under transmitted light, without setæ, but with numerous minute sensory hairs, subequal in length to the preceding four joints taken together or to the second joint; remaining eight small joints each slightly longer than broad and barrel-shaped, subequal in size and shape to

each other, pale brown on the proximal part and brown on the distal margin; two short hyaline sensory hairs arranged on the distal margin of each joint from second to ninth.

Hypopygium very large, occupying about one-third of the abdomen, turned through about 80°; penultimate sternite broad, with a somewhat U-shaped thickening, without setæ; ultimate tergite small and with about three pairs of small setæ; ultimate sternite located between the large coxites, elongated caudad, forming a large tube of penis, covered entirely with slender microtrichiæ; coxites large, firmly united to each other, immovable independently, dark brown, covered entirely with velutinous hairs; styles (Plate 2, fig. 10) triangular, folded inward, each articulated on the laterocaudal tip of the coxite, thickly covered with velutinous hairs and on the dorsal side scantily covered with slender setæ besides the velutinous hairs, on the caudal angle of the style with about eight minute teeth which are erected dorsad and on the mesal margin with a minute tooth near the cephalic angle; parameres very small, firmly united to each other on the proximodorsal side of the penis tube; apophysis slightly chitinized, located along the dorsolateral sides of the penis tube.

Lengths of leg joints.

[44 units=0.7 mm. *38 units=0.1 mm.]

Leg.	Joint.									
	Coxa.	Trochanter.	Femur.	Tibia.	Tarsus.					
					1st.	2d.	3d.	4th.	5th.	Total.
Fore	15	10	27	41	*50	*20	*15	*12	*30	20
Middle	10	6	35	33	*40	*18	*15	*12	*30	19
Hind	10	9	39	35	*50	*20	*27	*12	*30	22

Legs comparatively stout, general coloration pale greenish brown; coxæ, trochanters, and all the articulations of the legs more or less brown; femora of the forelegs and femora and trochanters of the posterior four legs with rows of strong setæ; tibial spurs present, one on each leg, strongly curved at tip, similar in shape and size to each other on three pairs, each with one or two small setæ before the tip, spinous on its proximal half; tarsal joints more or less bilobated on the distal end, spe-

cially distinctly lobated on the ultimate joint, which is cordiform; third tarsal joint of the hind legs constricted on the dorsal side before the distal tip. Claws large, unserrated and distinctly curved, each with a peculiar large lamella and a tuft of several hyaline setæ on its ventral side; empodium large and spinose, as large as the claws; pulvilli wanting.

Wings (Plate 1, fig. 1) slightly brown under transmitted light, 1.7 mm long, very broad, without macrotrichiæ excepting the marginal setæ; squama large and completely bare; anal angle well developed and sharp, separated from the alula by a narrow area; vein R_{4+5} almost straight, not long, subequal in length to R or about twice as long as R_1, ending on the costal margin far before the wing tip; M_{1+2} sinuous, atrophied slightly before the wing tip; fCu located slightly beyond the level of r-m and about on the middle of the wing, its two branches, M_{3+4} and Cu_1, atrophied before the wing margin; Cu_1 curved caudad slightly; 1A extending scarcely beyond the base of fCu, curved caudad at its tip and parallel to Cu_1.

Habitat.—Seashore between the tide marks, Japan.

Holotype.—Male; Seto, Wakayama Prefecture; May 20, 1927.

Paratopotypes.—Males; May 20, 1927.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University; collected by Prof. Dr. Hachiro Yuasa.

This species is closely related to *Clunio marinus* Haliday and *C. adriaticus* Schiner, especially in the structure of the antennæ, but distinctly different from these species in the structure of the wing. General shape of the wing of the related species is comparatively slenderer than in the Japanese species; vein R_{4+5} of the above two species far longer than the proximal section of M or R, ending near the wing tip, while in the present species vein R_{4+5} is very short, ending far before the wing tip, so that the distance between the tips of R_{4+5} and M_{1+2} is comparatively far greater than in the above species; moreover, vein M_{3+4} is more strongly curved in the related species than in the Japanese species. Another allied species is *C. pacificus* Edwards, but the two differ distinctly in the relative length of the antennal joints: ultimate joint of the allied species is long and fully as long as the preceding seven joints taken together, while in the Japanese species it is subequal in length to the preceding four joints taken together or to the second joint itself.

CLUNIO TSUSHIMENSIS sp. nov.

This fly has been collected at ebb-tide on the rocky seashore of Tsushima Island where the rocks are covered with sea algæ. The immature forms and females have not been obtained.

Male.—Body about 1.5 mm in length and very scantily haired; general coloration pale greenish brown; supra-alar setal group of the mesothorax represented by three small setæ; scutellum pale brown, setigerous with brownish black hairs; halteres pale green.

Head small and round. Mouth parts atrophied. Maxillary palpi not segmented, pale brown on the distal half, with two or three minute setæ. Eyes round and covered with velutinous hairs; distance between eyes subequal in length to the vertical length of the eyes (11: 10). Antennæ (Plate 1, fig. 7) 10-segmented (excepted antennariæ), without plumose hairs; antennaria triangular in the frontal aspect and brown; scape also brown, with several hyaline sensory setæ and longer than its diameter; pedicel generally pale green, about one and one-half times as long as the scape, with two small setæ on the distal part and brown on the distal margin; ultimate joint pale brown under refracted light, very long, twice as long as the preceding seven joints taken together or subequal to the preceding eight joints taken together; A.R. about 0.87; each joint from third to ninth pale green, shorter than its diameter and with a pair of small hyaline sensory hairs on its distal margin.

Hypopygium (Plate 2, fig. 13) very large and brown; styles (Plate 2, fig. 11) somewhat elongated, triangular, with several (5) minute teeth on the caudal corner and a small tooth on the mesal margin near the cephalomesal corner.

Relative length of the joints of the legs are shown in the following table:

Lengths of leg joints.

[44 units=0.7 mm. *88 units=0.1 mm.]

Leg.	Joint.									
	Coxa.	Tro-chanter.	Femur.	Tibia.	Tarsus.					
					1st.	2d.	3d.	4th.	5th.	Total.
Fore	12	7	26	36	*50	*17	*16	*13	*20	19
Middle	12	6	31	30	*35	*15	*14	*11	*20	15
Hind	12	7	34	32	*41	*18	*30	*12	*21	20

General coloration of the legs pale greenish brown; coxæ, trochanters, and all the articulations between the joints brown; tibiæ each with a spur, which is slightly curved at tip, spinose on its proximal half and without isolated setæ. Claws unserrated, distinctly curved ventrad, each with a large hyaline lamella and a tuft of hyaline setæ on its ventral side; pulvilli wanting; empodium as large as the claws.

Wings (Plate 1, fig. 2) broad; anal angle well developed and sharp; squama quite bare. Vein R_{4+5} shorter than the proximal section of M, straight, ending on the costal margin far before the wing tip; distal section of M (M_{1+2}) long, almost straight, very slightly curved upwards, ending near the wing tip, so that the distance of its tip from the tip of R_{4+5} is much greater than from the tip of M_{3+4} and equal to the length of R_{4+5}; fCu located beyond r-m; Cu_1 distinctly curved caudoproximad; 1A almost straight, only the tip curved.

Habitat.—Rocky seashore under the high tide mark, Japan.

Holotype.—Male; May 28, 1930.

Paratopotypes.—Males; May 28, 1930.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University, and in the entomological laboratory, Kyushu Imperial University; collected by Prof. Dr. Teizo Esaki.

This species is closely allied to *Clunio pacificus* Edwards and *C. setoensis* Tokunaga except in the very long ultimate joint of the antenna and distinctly recurvate Cu_1.

CLUNIO TSUSHIMENSIS var. MINOR var. nov.

This fly was very abundant in the summer season on the algal matting of the rocky seashore under the high tide mark at Seto, Wakayama, Japan. Large colonies of this fly were found generally on the level occupied by the zone of an alga, *Tubinaria* (?) *fusiformis* Yendo. The majority of the imagines of both sexes emerged soon after the algal matting was exposed to the air by the recession of the tide, and their swarming was often observed even under the direct sunshine. The males were running with fluttering wings or lowly skimming over the algal matting, single or in copula. Copulation is end to end in position and lasted about two or three minutes. Several males sometimes made a mass entangling with each other around one female. Eggs are laid out at one time immediately after the copulation and they are arranged in a single file in a very sticky gelatinous cord.

Immature forms, pupæ (males and females) and larvæ, are found in the tubelike nest cases built with silky threads binding the débris of algæ and diatoms. Larvæ often suspend themselves in the water by the sticky strong silky threads when they are disturbed. In one colony various stages of larvæ are found besides the pupæ and imagines at the same time.

Male.—Excepting the antennæ, the characters of the male are nearly identical with those of the typical species. Body 1 to 1.3 mm in length; coloration pale greenish brown generally. Eyes small, round, separated from each other by a distance equal to the vertical length of the eyes (10 : 9). Antennæ (Plate 1, fig. 8) 10-segmented (excepting the antennariæ); A.R. 1.03 to 1.04; second antennal joint with two small setæ on its distal part and brown on the distal margin; third to ninth joints very short, each half as long as its diameter and with a pair of small hyaline sensory hairs; ultimate joint very much elongated, more than half the length of the antenna.

Wings broad, 0.9 to 1 mm in length; milky white in life and pale brown under transmitted light.

Female.—Body yellowish white generally without conspicuous macrotrichiæ, 1 to 1.3 mm in length and with short legs. Wings absent. Head very small and round. Eyes very small, consisting of about ten facets and very widely separated from each other. Paired eyelike spots each located on the gena. Maxillary palpi greatly reduced and without setæ. Antennæ (Plate 1, fig. 9) very small, 5-segmented; antennaria reduced into uniform membrane; scape subequal in length to its diameter; pedicel with one minute seta on its middle part, shallowly constricted at the proximal part and twice as long as the scape; ultimate joint somewhat elongated but shorter than the pedicel.

On the abdomen, seventh sternite covered with minute soft hairs; eighth sternite brown, completely separated into lateral parts by the depression of the genital chamber; ninth segment membranous and somewhat elongated; paraprocts very small, contiguous, located between the cerci; spermatothecæ two, oval, brown, their ducts also brown; cerci (Plate 2, fig. 12) small, not pointed caudad but somewhat produced ventrad and very scantily haired.

Tibial spurs completely wanting; claws dark brown, each with one to two minute setæ on the ventral side and without lamella; empodium very short, hardly half as long as the claws.

Lengths of leg joints.

[38 units=0.1 mm.]

Leg.	Joint.								
	Coxa.	Tro-chanter.	Femur.	Tibia.	Tarsus.				
					1st.	2d.	3d.	4th.	5th.
Fore	31	20	58	44	6	6	6	6	13
Middle	25	19	60	39	5	5	5	5	12
Hind	31	19	60	41	6	5	4	6	14

Habitat.—Rocky seashore on the tidal zone, Japan.

Holotype.—Alcoholic male; Seto, Wakayama Prefecture; August 23, 1930.

Allotopotype.—Alcoholic female; August 23, 1930.

Paratopotypes.—Males and female; August 23, 1930.

Type specimens.—Alcoholic and dry; deposited in the entomological laboratory, Kyoto Imperial University, the entomological laboratory, Kyushu Imperial University, and the British Museum; collected by M. Tokunaga.

This variety is closely similar to the type form, from which it differs only in the exceedingly long ultimate antennal joint and in the far smaller size.

Genus TELMATOGETON Schiner

TELMATOGETON JAPONICUS sp. nov.

This fly was found in association with various marine algæ, such as *Ulva* sp. and *Monostroma* sp., on rocky shore between the tide marks of the coasts of the Pacific Ocean and the Japan Sea. Immature forms were nesting among these algæ and imagines were running on or flying low over the rocky shore. Sometimes imagines were collected by a light screen ashore at night, and many larvæ were reared to the imaginal stage in a glass aquarium. Morphologically the immature forms closely resemble those of the other *Telmatogeton* species and *Paraclunio* species.

Male.—Body 2.9 to 4.3 mm in length, scantily haired; general coloration black; thorax very slightly pruinose; halters yellow; scutellum and legs brownish black; wings clouded entirely black.

Head round; vertex dark; clypeus brownish black, transversely large, with many black setæ; tormæ distinctly chitinized and quite smooth; postgenæ each with a black spot. Eyes bare, hemispherical, widely separated, distance between them subequal to the vertical length of the eyes. Antennæ (Plate 1, fig. 5)

black on the cephalic side and brown on the caudal side, very scantily haired but with many hyaline sensory hairs on the flagella, 7-segmented (excepting the narrow antennariæ) ; distal joint brown but its tip black, with one small apical seta and three long setæ on its proximal part, subequal in length to the preceding three or four joints taken together, antennaria very narrow and without setæ; scape very setigerous, subequal in length to the next joint and to the diameter of the scape itself; joints from second to sixth without setæ; second joint deeply constricted into two parts, proximal part without sensory hairs, while the distal part with many sensory hairs; following four joints moniliform, each shorter than the diameter of each joint. Maxillary palpi (Plate 1, fig. 6) brown on the dorsocephalic side and pale brown on the ventrocaudal side; 2-segmented; proximal joint black, spherical, with many black setæ; distal joint slender, half as wide as the proximal joint and four times as long as its own diameter, brown, with a few setæ on its distal half. Paraglossæ pale brown, very small, and with several minute setæ.

Pronotum separated into small, paired, lateral lobes, which are setigerous with several small setæ. Præscutum of the mesothorax very scantily haired, with three to four short setæ arranged along each of the pseudosutural foveæ; postscutum not distinctly bounded from præscutum, often with two small setæ on its caudomeson; supra-alar setal group represented by two to five small setæ; scutellum brown or blackish brown, very setigerous with black setæ.

Tip of the abdomen turned through 65° to 85° sinistrad, but rarely dextrad, between the seventh and ninth segments. Caudal two tergites of the abdomen reduced almost to membrane but the sternites chitinized and covered with minute setæ. Hypopygium (Plate 2, fig. 14) without long setæ, entirely covered with minute setæ, without secondary appendages. Coxites very large and stout, each with blunt projection on its dorso-proximo-mesal margin; styles small, folded inwards, without teeth or hooks, setæ on the mesal side curved and somewhat longer than those on the lateral side; anal tube large and prominent; tube of penis exposed between the coxites or caudad of the anal tube, guarded by a pair of slightly chitinized apophyses.

Legs stout and long, covered entirely with small setæ. Of the forelegs, coxæ large and femora somewhat clavate on the proximal part; tibiæ of the anterior four legs each with a single spur which is not curved but quite straight, spinous on its proximal half and subequal in length to the diameter of the tibia;

tibial spurs of the hind legs two on each leg, lateral spur slightly shorter than the mesal which is subequal in length to those of the other legs; tarsal joints each with a pair of small spines on its distoventral margin; third and fourth joints somewhat cordiform; ultimate joints of the legs all trilobated; median lobe very large, occupying about half the length of the fifth joint, covering the empodium; two lateral lobes unequal in size, the cephalic one is one-half, while the caudal one is one-fourth as large as the median lobe; empodium very large, pectinately plumose, extended as far as the median lobe; claws (Plate 2, fig. 16) asymmetrical, cephalic claw bifurcated into a long simple claw and a small spatulate comb, while the caudal claw is divided into a small simple claw and a large spatulate comb. Besides the above structures there are two prominent setæ, each of which is fully as long as the large claw, being located between the lobes and two elongated triangular lamellæ, which are fully as long as the median lobe; these lamellæ may be homologous with the pulvilli judging from their location.

Lengths of leg joints.

[50 units=1 mm.]

Sex and leg.	Joint.								
	Coxa.	Tro-chanter.	Femur.	Tibia.	Tarsus.				
					1st.	2d.	3d.	4th.	5th.
Male:									
Fore	20	9	71	67	35	14	8.0	7.0	11.0
Middle	15	8	105	81	33	12	7.0	6.0	11.0
Hind	16	9	102	85	40	20	7.5	6.0	10.0
Female:									
Fore	20	9	55	51	28	11	7.0	6.5	10.5
Middle	15	9	85	60	25	10	6.0	5.5	11.0
Hind	15	9	92	75	36	19	7.0	6.0	11.0

Wings (Plate 1, fig. 3) 2.1 to 4 mm in length, covered entirely with black microtrichiæ, brown under transmitted light, fringed with minute hairs; squama large, fringed with many small setæ; alula distinct; anal area well developed; anal angle distinctly developed and somewhat pointed. Cephalic veins black, caudal veins brown; veins R, R_1, and R_{4+5} strong, with several small setæ; distal tip of cell R_3 sharply pointed, R_{4+5} very long, longer than twice R_1 (56 : 24), ending a little before the wing tip or about on the same level with the tip of M_{1+2}, slightly curved along the costal margin; basal section of Rs very short

but wide; r-m oblique in position and very long; distal section of M (M_{1+2}) about one and one-half times as long as the proximal section of M (32 : 21), almost straight, very gradually curved caudal; M_{3+4} distinctly curved caudad, ending with a right angle on the caudal margin; fCu narrow, located just caudad of the proximal end of r-m; 1A sinuous, ending far beyond the base of fCu.

Female.—Closely resembling the male in structure and coloration of the head, thorax, legs, wings, etc., but different in the following points:

Body 3 to 4 mm in length. Ultimate segment of the abdomen thinly chitinized generally, conical, very scantily haired; setæ on the caudomesal part of the ultimate tergite somewhat longer than those on the other parts, cephalic margin of the same tergite thickly chitinized and black; telson, cerci, and ventral valves small, forming a conical common projection, ovipositor together; cerci (Plate 2, fig. 15) elongated caudad, as long as the ventral valves and about twice as long as the telson, setigerous entirely with minute setæ, each articulated with a thickened cercaria to the tip of the ultimate segment. Claws of the legs large, symmetrical, not serrated or furcated but quite simple; measurement of the legs as shown already. Wings comparatively broader than in the male, about 2.2 to 3 mm in length.

Habitat.—Seashore between the tide marks, Japan.

Holotype.—Male; Karo, Tottori Prefecture; July 4, 1931.

Allotopotype.—Female; July 3, 1931.

Paratypes.—Male and females; Karo, Tottori Prefecture; July 3 to 7, 1931; and Seto, Wakayama Prefecture; June 20, 1930.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University, the entomological laboratory, Kyushu Imperial University, and the British Museum; collected by M. Tokunaga.

This fly is allied to *Telmatogeton sancti-pauli* Schiner but differs distinctly in the venation, especially in the position of fCu, which is located far before the level of r-m in the allied species. The related Hawaiian torrential species, *T. abnorme* Terry, differing in the shape of the tarsal claws of the male; in the Japanese species the bifurcation of the claws is deeper than in the torrential species. Another species, recently reported by Edwards from Ancud, southern Chile, *T. trochanteratum* Edwards, is somewhat similar to the present species but easily distinguishable by the presence of the peculiar thumblike projection of the middle trochanter in the Chilian species.

ILLUSTRATIONS

[Drawings by M. Tokunaga.]

PLATE 1

FIG. 1. *Clunio setoensis* sp. nov., wing, male.
2. *Clunio tsushimensis* sp. nov., wing, male.
3. *Telmatogeton japonicus* sp. nov., wing, male.
4. *Clunio setoensis* sp. nov., antenna with antennaria, male.
5. *Telmatogeton japonicus* sp. nov., antenna with antennaria, male.
6. *Telmatogeton japonicus* sp. nov., maxillary palpus, male.
7. *Clunio tsushimensis* sp. nov., antenna with antennaria, male.
8. *Clunio tsushimensis* var. *minor* var. nov., antenna with antennaria, male.
9. *Clunio tsushimensis* var. *minor* var. nov., antenna without antennaria, female.

PLATE 2

FIG. 10. *Clunio setoensis* sp. nov., style, male, dorsal aspect.
11. *Clunio tsushimensis* sp. nov., style, male, dorsal aspect.
12. *Clunio tsushimensis* var. *minor* var. nov., cerci, female, dorsal aspect.
13. *Clunio tsushimensis* sp. nov., hypopygium, male, sternal aspect.
14. *Telmatogeton japonicus* sp. nov., hypopygium, male, tergal aspect.
15. *Telmatogeton japonicus* sp. nov., hypopygium, female, lateral aspect.
16. *Telmatogeton japonicus* sp. nov., tarsal claws of the left middle leg, male, ventral aspect.

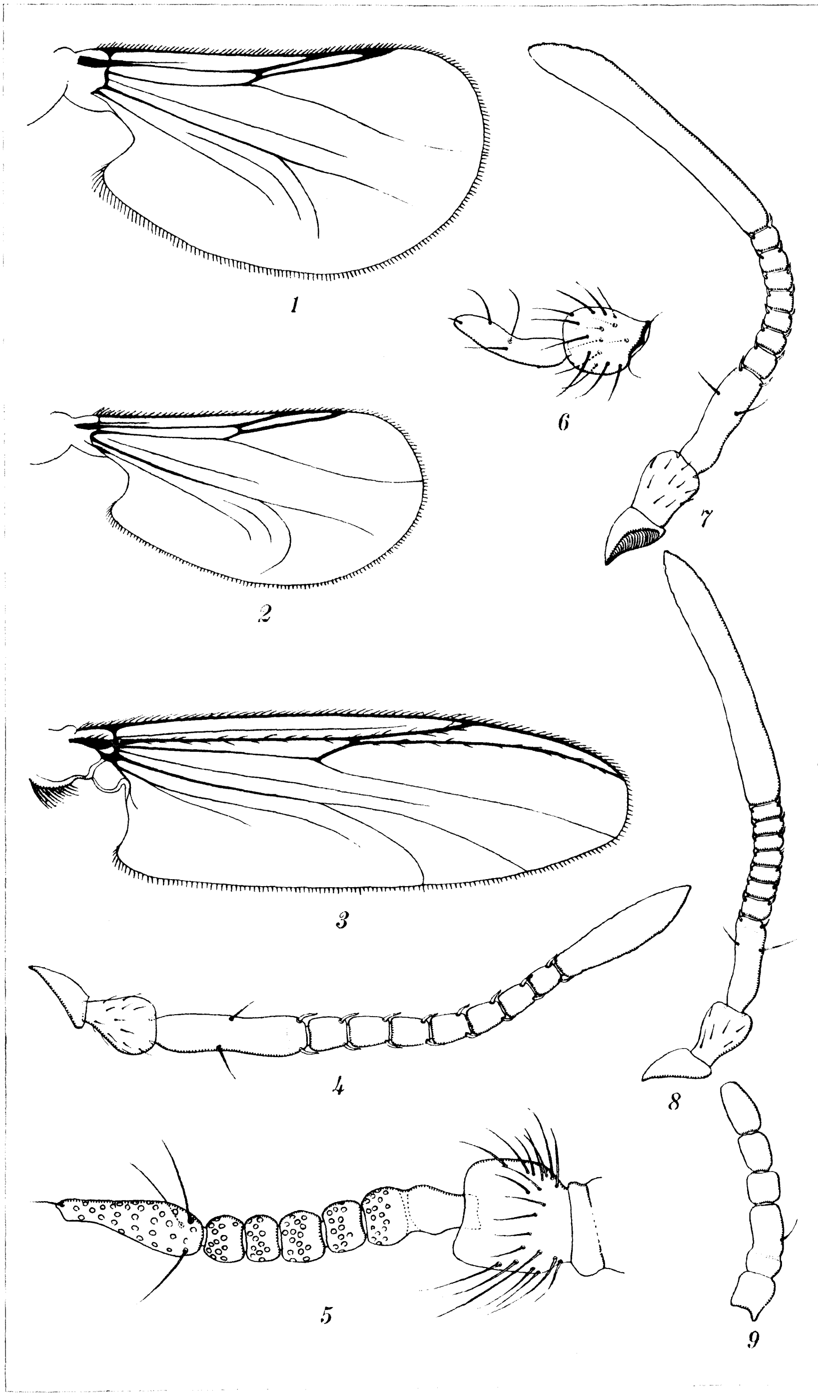
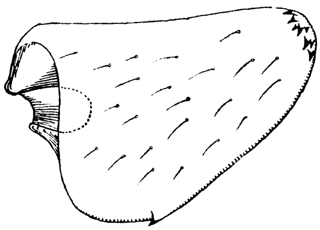


PLATE 1.



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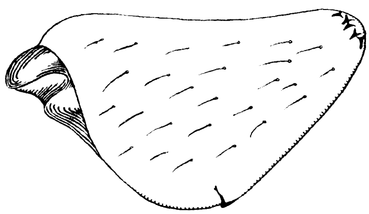

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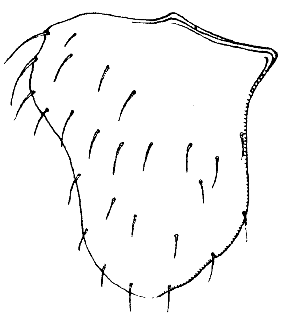

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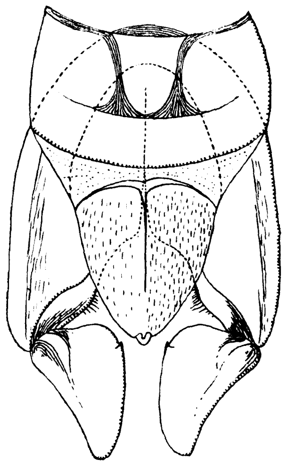

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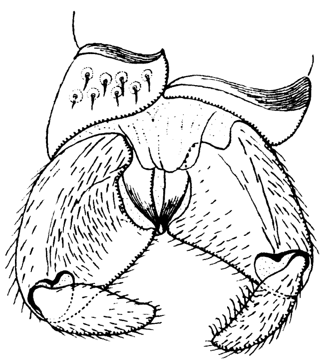

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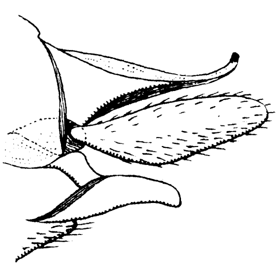

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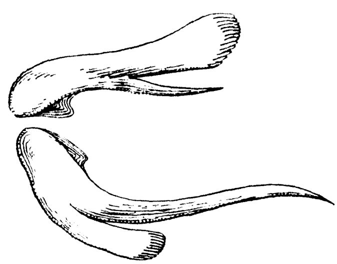

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PLATE 2.

NEW SCOLYTIDÆ FROM THE PHILIPPINES

By Karl E. Schedl

Of the Entomological Branch, Department of Agriculture, Ottawa, Canada

ONE PLATE

By the courtesy of Mr. F. C. Hadden, assistant entomologist for the Experiment Station of the Hawaiian Sugar Planters' Association, who was then temporarily residing at the Agricultural College, Laguna Province, Philippine Islands, I have been able to examine his collection of the families Scolytidæ and Platypidæ, all specimens of which were collected in the Philippine Islands or in Honolulu. I tender my thanks to Mr. Hadden for placing his collection at my disposition; descriptions of some of the new species and new localities for known forms are given in this paper.

XYLEBORUS HADDENI sp. nov.

Description of the female beetle.—Very shining, reddish brown, 2 mm long, twice as long as broad, glabrous except the anterior part of the pronotum and the sides of the elytra, which bear scattered hairs. Allied to *Xyleborus dossuarius* Egg., *quadrispinosulus* Egg., and *javanus* Egg.

Front plano-convex, minutely reticulate, with a few scattered punctures above the epistomal margin, pubescence scanty, except for a fringe along the epistomal margin. Eyes short oval, with a deep but narrow emargination in front. Antennæ yellowish, scape distinctly shorter than the funiculus and club united, second joint of the former distinctly longer than the following ones, club subcircular, truncate portion squamose, with one indistinctly visible suture.

Pronotum globose, 1.18 times wider than long, widest near the base, the latter truncate, posterolateral angles nearly rectangular, feebly rounded, sides uniformly rounded from the base to the apex, the apical margin extended and armed with six asperities, the two median of which are decidedly longer; summit

at the middle, anterior area rather coarsely asperate, posterior area minutely reticulate and with very fine, remotely placed punctures, median line hardly noticeable. Scutellum moderate in size, triangular.

Elytra as wide and 1.4 times as long as the pronotum, sides parallel, feebly arcuate, on the anterior three-fourths, apex distinctly angulate; disc ascending on the basal fourth, followed by a transverse impression like that in *dossuarius* Egg., declivity commencing slightly before the middle, oblique, hind margin and sides, up to the seventh interstice, acute, sharp; anterior fourth, before the transverse impression, irregularly punctured, shining, punctures not closely placed, transverse impression densely, rugulosely punctured, the sides coarsely remotely punctured with indications of rows; on the upper margin of the declivity the second and third interspaces widened, the second interspace armed with a small tuberclelike tooth, a decidedly larger tooth on the third interspace; while the former is near the posterior border of the transverse impression, the latter is already on the declivity face; declivity subshining, coarsely striate punctate, interstices flat, minutely, uniseriately punctate, the apical corner of the declivity elevated, suture feebly granulate at the extreme tip.

From its relatives this species is easily separated by its declivital armature. The sex has been determined by dissection of a paratype.

Holotype.—Female, Mount Maquiling, Laguna, Luzon, August 26, 1930, from branches of kalantas, *Toona calantas* Merr. and Rolfe; F. C. Hadden, collector.

Paratypes.—Six females with the same label; 4 from the same locality and host but collected, apparently, at another altitude.

XYLEBORUS DUPLICATUS sp. nov.

Description of the female beetle.—Pronotum black, elytra very dark brown, underside somewhat lighter, 4.3 mm long, twice as long as wide; allied to *X. hybridus* Egg.

Front plano-convex, strongly shining, with a smooth, feebly elevated median carina, just above the epistomal margin, between the eyes coarsely punctured and with scattered long hairs, a fringe of hairs also along the epistomal margin. Eyes short oval, emarginated in front. Antennæ reddish brown, scape shorter than the funiculus and club united, second segment of the funiculus very elongate, nearly as long as the remaining joints together, club slightly wider than long, truncate portion squamose, with indications of sutures.

Pronotum subquadrate, slightly wider than long (64:60), base and apex truncate, sides feebly arcuate, somewhat narrowed towards the apex, lateral angles subsimilarly rounded; summit high, behind the middle, anterior margin with no conspicuous asperities, anterior area steep, densely but rather finely asperate, posterior area minutely reticulate, with very fine and remotely placed punctures, median line not at all elevated, impunctate, a row of coarse punctures along the basal border; pubescence, which is restricted to the sides and the anterior area, scanty but long. Scutellum cordate, black and impunctate.

Elytra as wide and 1.68 times as long as the pronotum, base truncate, humeral angles rectangular, sides subparallel, slightly arcuate, on the anterior three-fourths, apically somewhat angulately rounded; ascending on the basal fourth, then uniformly rounded to the apex, basal fourth shining, apical portion subshining, opalescent, on the declivity suture feebly elevated, second interspace slightly impressed; distinctly striate-punctate throughout, punctures shallow but very closely placed, striæ impressed, slightly more on the declivity, interspaces flat, uniseriately punctate on the basal fourth, replaced by small tubercles on the apical three-fourths, apical margin acute. Anterior tibiæ widened distally with six small teeth on the outer edge beside the apical spur.

From *X. hybridus* this species is easily distinguished by the size, less-flattened declivity, shape of the pronotum, and the opalescent apical portion of the elytra.

Holotype.—Female, Mount Maquiling, Laguna, Luzon, June 11, 1931, from tibig, *Ficus nota* (Blanco) Merr., and balobo, *Diplodiscus paniculatus* Turcz.; F. C. Hadden, collector.

Paratypes.—Many females, with the same label.

XYLEBORUS NEPOS Egg. var. ROBUSTUS var. nov.

Eight specimens, which were taken on Mount Maquiling, Laguna, Luzon, July 16 and 26, 1930, by F. C. Hadden, correspond with the original description of *X. nepos* Egg., but show the following differences:

The pronotum is distinctly wider than long, the apical margin of the elytra is rather acute, and the form is even a little stouter than in *X. interjectus* Blandf. and not slenderer than *interjectus* as *nepos* should be according the description of Eggers.

XYLEBORUS INDICUS Eichh.

Two specimens with the label Mount Maquiling, Laguna, Luzon, August 19, 1930, 400 feet elevation, from white nato,

Sideroxylon macranthum Merr., F. C. Hadden, collector, agree perfectly with Eichhoff's description. A third specimen, with the same label, seems to be the hitherto undescribed male.

Description of the male beetle.—Yellowish brown, depressed, 1.83 mm long, 2.77 times as long as wide.

Front plano-convex, finely reticulate, with few distinct punctures.

Pronotum semielliptical, longer than wide (26: 23), slightly convex, applanate towards the apex, the latter unarmed, finely asperate in front, rather densely hairy; polished and finely punctured behind.

Elytra as wide and 1.8 times as long as the pronotum, sides parallel on the anterior four-fifths, rather angulately rounded behind, with a very small emargination at the tip of the apex; subcylindrical on more than the basal half, then obliquely declivous; striate throughout, striæ not at all impressed on the disc, distinctly so on the declivity, interspaces impunctate on the disc, convex and finely tuberculate on the declivity, apical margin acute.

The base of the pronotum is distinctly but shallowly emarginate; the anterior tibiæ slender, narrow, very finely dentate on the outer edge.

COCCOTRYPES PHILIPPINENSIS sp. nov.

Description of the adult female.—Bright reddish brown, 1.95 mm long, 2.25 times as long as wide, allied to *C. uniseriatus* Egg.

Front plano-convex, longitudinally aciculate, with slight indications of a smooth median carina, rather rugulosely punctured and with interspersed hairs. Eyes large, broadly oval, slightly emarginate in front. The antennæ are remarkable in as much as the club is 1.36 times as wide as long.

Pronotum 1.12 times as wide as long, widest behind the middle, base truncate, posterolateral angles moderately rounded, sides subparallel on the basal third, feebly constricted towards the base, rather strongly constricted towards the apex, obtusely rounded in front; apical margin unarmed, surface rather feebly convex, asperate and sparsely hairy over the entire surface, with no indications of concentric arrangement, median line indistinct, sides subacute. Scutellum small, triangular, smooth.

Elytra distinctly wider (32: 29) and 1.76 times as long as the pronotum, sides parallel on more than the basal half, then somewhat constricted, slightly angulately rounded behind; cylin-

drical on more than the anterior half, declivity evenly convex, feebly applanate; strial punctures coarse, in regular rows, moderately closely placed, hardly impressed on the disc, distinctly so on the declivity, especially the sutural striæ, the strial punctures bear no setæ, interspaces as wide as the diameter of the strial punctures, very feebly rugose near the base, uniseriately punctured on the disc, towards the declivity these punctures become minute tubercles, all interstrial punctures and tubercles bear long, erect setæ, the interstrial punctures are more remotely placed, distance from one to the other about one and one-half times the diameter of one strial puncture; suture slightly elevated towards the apex of the declivity.

I am inclined to place this species close to *C. uniseriatus* Egg. The latter can be separated from *philippinensis* by the shape of the pronotum, the size, the proportions of the elytra, and the punctuation.

Holotype.—Female, Mount Maquiling, Laguna, Luzon, August 16, 1930, from seeds of malaruhat-puti, *Eugenia similis* Merr.; F. C. Hadden, collector.

Paratypes.—Many, with the same label.

RECORDS OF DESCRIBED SPECIES

PLATYPUS SETACEUS Chap.

Mount Maquiling, Laguna, Luzon, Philippine Islands, July 11, 1931, from balobo; F. C. Hadden, collector.

PLATYPUS SOLIDUS Walk var. EXILIS Chap.

Same locality and collector, July 16 and 30, August 6, and December 26, 1930; March 3, 1931.

PLATYPUS JANSONI Chap.

Same locality and collector, June 26, July 16 and 19, October 1 and 27, 1930.

CROSSOTARSUS FRAGMENTUS Samps.

Same locality and collector, one specimen, July 16, 1930.

CROSSOTARSUS LECONTEI Chap.

Same locality and collector, June 11, 1931, from *Sideroxylon macranthum.*

XYLEBORUS SEXSPINOSUS Motsch.

Same locality and collector, July 26, 1930, from *Toona calantas.*

XYLEBORUS HYBRIDUS Egg.

Same collector and locality, August 16, 1930, June 11, 1931.

XYLEBORUS DOSSUARIUS Egg.

Same locality and collector, August 26, 1930, from *Toona calantas.*

XYLEBORUS EXIGUUS Walk.

Same locality and collector, September 29, 1930, from *Toona calantas.*

XYLEBORUS SIMILIS Ferr.

Same locality and collector, August 16 and 19, 1930, from *Sideroxylon macranthum.*

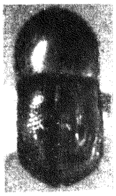
COCCOTRYPES DACTYLIPERDA Fabr.

Honolulu, Hawaii, July 9, 1926, from *Persea gratissima* Gaertn.

ILLUSTRATION

PLATE 1

FIG. 1. *Xyleborus haddeni* sp. nov.
2. *Xyleborus haddeni* sp. nov.
3. *Xyleborus duplicatus* sp. nov.
4. *Coccotrypes philippinensis* sp. nov.
5. *Xyleborus nepos* var. *robustus* var. nov.
6. *Xyleborus duplicatus* sp. nov.
7. *Xyleborus haddeni* sp. nov.
8. *Coccotrypes philippinensis* sp. nov.



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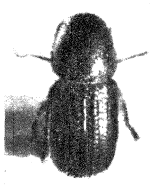

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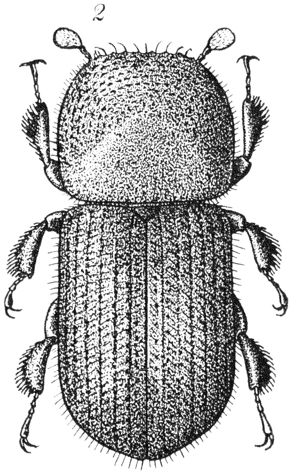

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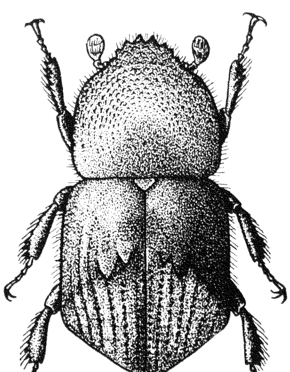

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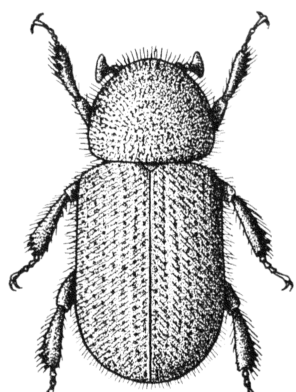

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PLATE 1.

NEU BEKANNT GEWORDENE RHYNCHITINEN UND ATTELABINEN DER ORIENTALISCHEN REGION (COLEOPTERA; CURCULIONIDÆ)

40. BEITRAG ZUR KENNTNIS DER CURCULIONIDEN

Von EDUARD VOSS

Berlin-Charlottenburg, Deutschland

RHYNCHITES (INVOLVULUS) EGENUS sp. nov.

Kopf quer, ziemlich kräftig und sehr dicht punktiert; Augen ziemlich kräftig vorgewölbt, wenig länger als die Stirn breit und diese so breit wie der Rüssel vor der Basis. Rüssel etwa so lang wie das Halsschild, kräftig und gleichmässig gebogen; basale Hälfte mit feinem Mittelkiel, der sich an der Fühlereinlenkung gabelt und seitlich von je einer Längsfurche begleitet wird. Fühler in der Mitte des Rüssels eingelenkt. Schaft- und 1. Geisselglied gleichlang, jedes fast doppelt so lang wie breit; 2. bis 4. Glied etwas kürzer; 5. und 6. Glied noch länger als breit; 7. Glied quer. Glieder der Keule erheblich länger als breit. Halsschild breiter als lang, seitlich ziemlich kräftig gerundet, zum Vorderrand mehr als zur Basis verschmälert; ziemlich kräftig und sehr dicht punktiert, mit feiner Mittelfurche. Schildchen quer, viereckig; fein und sehr dicht punktiert. Flügeldecken etwa anderthalbmal so lang wie breit, im basalen Teil parallelseitig, dann leicht gerundet verbreitert. Punktstreifen mässig stark, hinten etwas feiner, die Punkte schmal getrennt; Zwischenräume flach, breiter als die Streifen, sehr dicht unregelmässig punktiert, die Punkte ziemlich kräftig, doch feiner als diejenigen der Streifen. Pygidium in gleicher Weise wie die Zwischenräume der Flügeldecken punktiert. Tibien kräftig, gerade.

Färbung stahlblau; Rüssel, Fühler, Tibien und Tarsen schwarz, Schultern grün, Rüssel mit Erzglanz. Behaarung wenig dicht, doppelt: kürzer, nach hinten gerichtet, etwas langer, abstehend. Länge 5.5 mm.

CHINA, Hangchow (*Tsai*), April, 1930. In meiner Sammlung.

Den Arten der Untergattung *Haplorhynchites*, etwa dem *R. pubescens* F. ähnlich, doch vereinigt sich der vorletzte Punktstreif mit dem Randstreif vor der Mitte der Decken. Von dieser und der folgenden Art verdanke ich der Liebenswürdigkeit von Herrn Prof. Tsai das typische Exemplar, für die zu danken ich auch an dieser Stelle Gelegenheit nehmen möchte.

RHYNCHITES (RHYNCHITES) CONFRAGOSICOLLIS sp. nov.

Männchen.—Kopf breiter als lang, schwach konisch, kräftig und sehr dicht punktiert, die Stirn mit breiter, durch kurze Kiele begrenzte Furche. Augen schwach gewölbt, so lang wie die Stirn breit, diese schmaler als der Rüssel an der Basis dick. Rüssel kaum so lang wie Kopf und Halsschild zusammen, schwach gebogen, ziemlich kräftig und sehr dicht runzlig punktiert, Basalhälfte mit schwachem Mittelkiel. Fühler mittenständig; Schaft- und 1. Geisselglied gleichlang, jedes etwa anderthalbmal so lang wie breit; 2. bis 4. Glied etwas länger; 5. Glied wenig länger als breit; 6. Glied so lang wie breit; 7. Glied quer. Erstes Glied der Fühlerkeule länger als breit; 2. und 3. Glied so lang wie breit; Endglied zugespitzt. Halsschild breiter als lang, seitlich mässig stark gerundet, die grösste Breite liegt hinter der Mitte, zum Vorderrand mehr verschmälert als zur Basis und an demselben leicht eingeschnürt; hinter der Mitte oberseits mit breiterem V-förmigen Eindruck. Punktierung kräftig und sehr dicht. Schildchen trapezförmig. Flügeldecken etwa anderthalbmal so lang wie breit; von den Schultern ab kurz parallelseitig, dann schwach gerundet verbreitert. Punktstreifen mässig stark, die Punkte durch schmale Querrunzeln getrennt; Punktierung der Zwischenräume wenig schwächer, sehr dicht unregelmässig. Unterseite fein und sehr dicht punktiert. Tibien schlank und gerade.

Färbung grünmetallisch, stellenweise mit schwachem Kupferschein; Fühler schwarz. Behaarung mässig dicht, länger abstehend, greis. Länge 5.5 mm.

CHINA, Hangchow (*Tsai*), 7. Mai, 1930. In meiner Sammlung.

Eine Art aus der näheren Verwandtschaft des *R. bacchus* L. und dem *R. faldermanni* Boh. am nächsten stehend. Die Männchen beider Arten haben im Gegensatz zu *bacchus* einen etwas längeren, spitzen Seitendorn am Halsschild, flacher gewölbte und mehr seitlich stehende Augen. Unsere Art unterscheidet sich von *faldermanni* durch kürzeren Rüssel, flachere Augen, etwas schmalere Stirn, seitlich weniger gerundetes Halsschild

und etwas kräftigere Punktierung. *Rhynchites faldermanni* ist in der Regel purpurrot übergossen.

BYCTISCUS (TAIWANOBYCTISCUS) COMPLANATUS sp. nov.

Männchen.—Kopf mässig stark und sehr dicht, auf der Stirn längsrunzlig punktiert; Stirn schmaler als der Rüssel vor der Basis. Rüssel kräftig, nicht ganz so lang wie das Halsschild, oberseits vor der Fühlereinlenkung mit muldenförmiger Vertiefung; im basalen Teil auf dem Rücken glänzend, fein und wenig dicht punktiert. Fühler mittenständig. Schaftglied so lang wie breit; 1. Geisselglied etwas länger als das Schaftglied; 2. Glied kurz, wenig länger als breit und gut halb so lang wie das 1. Glied; 3. Glied etwas länger als das 1. Glied; 4. Glied kaum länger als das 2. Glied; 5. Glied kugelförmig; 6. und 7. Glied breiter als lang; 1. und 2. Glied fast so lang wie breit; 3. Glied mit dem Endglied so lang wie das 1. und 2. Glied zusammen. Halsschild breiter als lang, seitlich stark gerundet. Mitte mit schmaler punktfreier Mittelfurche; Punktierung mässig stark und sehr dicht. Schildchen quer, viereckig, fein und sehr dicht punktiert. Flügeldecken parallelseitig, etwa ein und ein Viertelmal so lang wie breit. Punktstreifen ziemlich kräftig, Punkte einzeln eingestochen, nicht furchig vertieft, schmal getrennt; Zwischenräume durchaus flach, die inneren sechs Zwischenräume viel breiter als die Streifen, sehr fein und mässig dicht, im Eindruck hinter dem Schildchen etwas kräftiger punktiert. Der vorletzte Punktstreif vereinigt sich mit dem Randstreif in der Höhe des 2. Abdominalsegments.—Pygidium kräftig und sehr dicht punktiert, ebenso auch Mittel und Hinterbrust mit Seitenteilen, das Abdomen dagegen feiner und weitläufiger.

Weibchen.—Halsschild viel feiner und weniger dicht punktiert.

Färbung stahlblau; Fühler, Tibien und Tarsen schwarz. Länge 5.5 mm.

CHINA, Shanhaikwan, in den Bergen (*Thomson*), September, 1906. British Museum (Natural History); in meiner Sammlung.

LISTROBYCTISCUS SULÆNSIS sp. nov.

Männchen.—Kopf sehr fein und dicht punktiert; Stirn schmaler als der Rüssel. Letzterer kräftig, so lang wie Kopf und Halsschild zusammen, mässig stark und sehr dicht punktiert, schwach gebogen, parallelseitig, an der Spitze schwach verbreitert, mit basalem Mittelkiel, begrenzt von seitlicher Längsfurche.

Fühler vor der Rüsselmitte eingelenkt. Schaft- und 1. Geisselglied gleichlang, anderthalbmal so lang wie breit; 2. bis. 4. Glied von gleicher Länge, etwas kürzer als das 1. Glied die restlichen Glieder so lang wie briet, zur Spitze allmählich an Stärke zunehmend. Erstes und 2. Glied der Fühlerkeule quer, 3. Glied mit dem Endglied so lang wie das 1. und 2. Glied zusammen. Halsschild so lang wie breit, seitlich mässig stark gerundet, die grösste Breite liegt hinter der Mitte, kurz vor dem basalen Drittel; Punktierung sehr fein und dicht. Die seitliche Bewehrung ziemlich kräftig. Schildchen quer, viereckig. Flügeldecken von den Schultern ab schwach geradlinig zur Mitte verbreitert, dann gerundet verschmälert. Punktstreifen vorn mässig stark, hinten sehr fein; Zwischenräume im basalen Teil fein und wenig dicht, undeutlich punktiert. Pygidium fein und dicht punktiert.

Färbung schwarz. Länge 3.6 mm.

SULA INSELN (*Wallace*). British Museum (Natural History).

In der Gruppe der *Listrobyctiscus*-Arten mit beim Männchen bewehrtem Halsschild hat diese Art mit dem *L. patruelis* m. von Formosa das zur Basis verschmälerte Halsschild gemeinsam und unterscheidet sich dadurch von allen übrigen Verwandten dieser Gruppe.

Eine weitere zur Gattung *Listrobyctiscus* gehörige Art ist der mir bislang unbekannt gebliebene—

LISTROBYCTISCUS ÆSTUANS (Pascoe).

Rhynchites æstuans PASCOE, Ann. & Mag. Nat. Hist. IV 15 (1875) 392.

Rüssel verhältnismässig kräftig, schwach gebogen, oberseits an der Basis ohne Mittelkiel und Furchen. Fühler mittenständig. Schaft- und 1. Geisselglied gleichlang, zusammen so lang wie der Rüssel an der Einlenkungsstelle dick; alle folgenden Glieder an Länge allmählich abnehmend. Glied 1 und 2 der Fühlerkeule so lang wie breit, das 3. Glied mit dem Endglied etwa drei Viertelmal so lang wie die 1. und 2. Glieder zusammen. Halsschild so lang wie breit, schwach konisch, wenig gerundet, nicht erkennbar punktiert. Flügeldecken von den Schultern ab gerundet zur Mitte verbreitert. Punktstreifen vorn ziemlich kräftig, nicht furchig vertieft, sondern die Punkte einzeln eingestochen, nach hinten zu feiner werdend, aber durch die Decken von der Unterseite in gleicher Stärke wie vorn durchscheinend.

Färbung bräunlichrot; Tarsen etwas angedunkelt. Länge 3.6 mm.

NORDOST-CELEBES, Menado (*Wallace*). British Museum (Natural History).

An dem einzigen mir vorliegenden Exemplar lässt sich das Geschlecht nicht feststellen, es scheint aber, als ob es sich um ein Männchen handelt und die Art damit der 1. Gruppe der Gattung mit beim Männchen unbewehrtem Halsschild zugehören würde. Die Tibien sind an der Spitze etwas verbreitert und leicht muldenförmig vertieft.

Bemerkenswert ist diese Art, weil es die einzige bisher bekannt geworden Art mit rotgelber Färbung in der Tribus Byctiscini ist.

PARAMECOLABUS (CATALABUS) ELEGANS sp. nov.

Männchen.—Kopf sehr fein zerstreut punktiert, Schläfen zylindrisch und der Kopf hinter den Augen fast so lang wie breit. Augen stark halbkugelförmig vorgewölbt, die Stirn schmaler als der Augenlängsdurchmesser, beiderseits mit einer Längsfurche, die sich seitlich auf dem Rüssel fortsetzt. Rüssel anderthalbmal so lang wie breit, von der Basis geradlinig nach vorn verbreitert, fein und dicht punktiert. Fühler im basalen Drittel des Rüssels eingelenkt. Schaftglied etwas länger als breit; 1. Geisselglied kugelförmig; 2. und 3. Glied verkehrt Gegelfömig, so lang wie das 1. Glied; die übrigen Glieder quer. Erster und 2. Glied der Fühlerkeule quer, das 3. Glied länger als den 1. und 2. Gliedern zusammen. Halsschild quer; seitlich kräftig geradlinig konisch nach vorn verjüngt, hinten schwielenförmig verrundet und der Postsegmentalring akut abgesetzt; Præsegmentalring durch scharfen Eindruck oberseits vom Scutum abgesetzt, letzteres beiderseits der Mitte mit je zwei in gleicher Höhe liegenden flachen Gruben. Punktierung undeutlich. Schildchen trapezförmig. Flügeldecken anderthalbmal so lang wie breit, parallelseitig. Punktstreifen mässig stark, die Punkte einzeln stehend; Zwischenräume flach, breiter als die Streifen, nicht erkennbar punktiert. Pygidium fein und mässig dicht punktiert. Vorderschenkel kräftig gekeult, viel stärker und länger als die übrigen; Vordertibien im apikalen Teil stark einwärts gebogen. Schenkel vor der Spitze mit kurzem, spitzem Zahn.

Weibchen.—Schläfen kürzer; Vordertibien kürzer und an der Spitze weniger scharf einwärts gebogen.

Färbung schwarz, Kopf und Halsschild erzglänzend; Flügeldecken rot. Länge 6 mm.

INDIEN, United Provinces, Kumaon, Nainital Div. (*H. G. Champion*). British Museum (Natural History); in meiner Sammlung.

Dem *P. simulatus* Mshl. am nächsten stehend und ihm sehr ähnlich, doch folgendermassen zu unterscheiden: Augen mehr vorgewölbt, die seitliche basale Schwiele des Halsschilds weniger exponiert, das Halsschild dadurch weniger konisch erscheinend; die Färbung des Abdomens mit dem übrigen Körper gleichfarbig schwarz, erzglänzend und das Tier im ganzen kleiner.

EUOPS (EUOPS) TONKINENSIS sp. nov.

Weibchen.—Kopf konisch, ohne Quereindruck, sehr fein zerstreut punktiert; Augen seitlich aus der Kopfwölbung nicht vorragend. Rüssel glänzend und unpunktiert, etwa doppelt so lang wie breit, von der Basis geradlinig nach vorn verbreitert. Fühler kurz vor der Rüsselbasis eingelenkt. Schaft- und 1. Geisselglied kräftig, etwas länger als breit; 2. und 3. Glied kaum kürzer als das 1. Glied; 4. und 5. Glied wenig kürzer als das 2. und 3. Glied; 6. und 7. Glied kaum so lang wie breit; 1. und 2. Glied der Fühlerkeule so lang wie breit; 3. Glied am längsten. Halsschild quer, stark konisch, am Vorderrand kaum halb so breit wie an der Basis, seitlich nur wenig gerundet; oberseits mässig stark und wenig dicht punktiert, seitlich kräftiger und dichter. Schildchen viereckig, so lang wie breit. Flügeldecken wenig länger als breit, schwach geradlinig nach hinten zu verschmälert; Zwischenräume viel breiter als die Streifen, kaum gewölbt, mässig stark einreihig punktiert. Hinterbrust mässig stark und sehr dicht punktiert, die vorderen Abdominalsegmente fein und weitläufig, die hinteren gedrängter punktiert. Pygidium fein und sehr dicht punktiert. Vordertibien gedrungen und breit, an der Spitze einwärts gebogen, die Mittel- und Hintertibien im ganzen nicht gebogen.

Färbung dunkelblau; Flügeldecken glänzend purpurrot, die Naht blau; Beine pechbraun. Länge 2.8 mm.

CHINA, Tonkin, Montes Mauson, 2,000 bis 3,000 Fuss Höhe (*Fruhstorfer*). Mus. Berlin (Coll. Moser); in meiner Sammlung.

Diese Art ist *Euops ignita* m. aus Birma sehr nahe verwandt. Während diese aber glänzende, unpunktierte Zwischenräume der Punktstreifen auf den Flügeldecken besitzt, hat unsere Art ziemlich kräftig punktierte Zwischenräume, die auch leicht gewölbt erscheinen; das Halsschild ist oben fein und dicht, seitlich sehr

dicht punktiert und auch das Abdomen weist eine kräftigere und dichtere, hinten sehr dichte Punktierung auf, auch ist *tonkinensis* grösser. *Euops gardneri* Mshl., Ind. Forest Rec. 16 (8) (1931) 263, scheint ebenfalls dieser Art sehr nahe zu stehen, aber ein weniger konisches Halsschild zu besitzen und *Euops fulgida* Faust ist ausser durch die gerundetere Form durch mehr gewölbt Zwischenräume auf den Flügeldecken zu trennen.

EUOPS (EUOPS) INSULARIS sp. nov.

Männchen.—Kopf glänzend, unpunktiert, hinter den Augen mit tiefer Einschnürung. Rüssel gut anderthalbmal so lang wie breit, in der basalen Hälfte schmal, parallelseitig, dann von der Mitte ab bis zur doppelten Breite der Basis nach vorn verbreitert, unpunktiert; von der Seite gesehen kräftig gebogen. Fühler kurz vor der Russelbasis eingelenkt. Schaftglied etwa anderthalbmal so lang wie breit; 1. Geisselglied etwas länger als breit; 2. bis 5. Glied so lang wie das 1. Glied; 6. Glied so lang wie breit; 7. Glied quer. Erstes Glied der Fühlerkeule etwas länger als breit; 2. Glied breiter als lang; 3. Glied mit dem Endglied etwas länger als das 1. Glied. Halsschild breiter als lang, die grösste Breite liegt in der Mitte, von hier nach hinten nur wenig verschmälert, nach vorn dagegen stark gerundet verengt, am Vorderrand kurz kragenförmig abgesetzt; oben glänzend, unpunktiert, seitlich ziemlich kräftig und sehr dicht punktiert. Schildchen breiter als lang, hinten konvex gerundet. Flügeldecken etwa ein und ein Viertelmal so lang wie breit, hinter den Schultern etwas eingezogen, dann gleichmässig schwach gerundet nach hinten verschmälert. Punktstreifen mässig stark, nach hinten zu feiner werdend; Zwischenräume wenig schmaler als die Streifen, unpunktiert. Hinterbrust mässig stark und sehr dicht punktiert, Abdomen fein und weitläufig, nur das letzte Segment dichter punktiert. Pygidium fein und dicht punktiert. Vordertibien schlank, gleichmässig gebogen; Mitteltibien zur Spitze keilförmig verbreitert, Hintertibien in der apikalen Häfte leicht einwärts gebogen.

Weibchen.—Augen kleiner, weniger vorstehend; Kopf hinter den Augen nicht abgeschnürt. Halsschild von der Basis ab fast halbkugelförmig verrundet. Mitteltibien an der Spitze nach innen spitz vorgezogen; Vordertibien nur im apikalen Drittel leicht gebogen.

Färbung schwarz, glänzend; Schildchen (Månnchen) grün; Fühler rot. Långe 2.5 mm.

ARU-INSELN. KEY-INSELN. Mus. Berlin (Coll. Moser); in meiner Sammlung.

Die Art ähnelt sehr *Euops nigra* m. von Australien, hat jedoch ein mehr verrundetes Halsschild, stärkere Punktstreifen und indere Kopfform, auch sind die Tibien anders gebildet.

EUOPS (EUOPS) SANDAKANENSIS sp. nov.

Weibchen.—Kopf glänzend und nur mit vereinzelten sehr feinen Punktchen versehen, auch der Rüssel glänzend und kaum erkennbar punktiert. Fühler an der Rüsselbasis eingelenkt. Schaft- und 1. Geisselglied gleichlang, kräftig, wenig länger als breit; die nächsten Glieder schwächer, das 2. bis 5. Glied jedoch noch länger als breit. Die Glieder der Fühlerkeule breiter als lang. Halsschild breiter als lang, kräftig konisch, seitlich geradlinig; obserseits sehr fein und weitläufig punktiert, seitlich etwas kräftiger und dichter. Schildchen so lang wie breit, hinten zugespitzt, unpunktiert. Flügeldecken wenig länger als breit, seitlich schwach gerundet. Punktstreifen besonders vorn sehr kräftig; Zwischenräume schmal, glänzend, unpunktiert, nach innen schräg abfallend. Mittelbrust fein chagriniert, mit einzelnen kräftigen Punktgruben; Hinterbrust sehr kräftig und sehr dicht punktiert, Abdomen sehr fein und wenig dicht punktiert, Pygidium fein und dicht punktiert. Vordertibien aussen schwach gebogen, kurz, in der Mitte innen stark verbreitert; Hintertibien schlank und gerade.

Färbung schwarz, glänzend. Länge 2.4 mm.

BORNEO, Sandakan (*Baker, 17122*). In meiner Sammlung; United States National Museum.

Diese Art steht in der Nähe von *Euops maculata* m., von den verwandten Arten durch die kråftigen Punktstreifen zu trennen.

EUOPS (SYNAPTOPS) KHARSU sp. nov.

Männchen.—Augen gross, kräftig, gewölbt. Rüssel so lang wie breit, von der Basis nach vorn kräftig verbreitert, gerade, abwärts gerichtet, fein und dicht punktiert. Fühler basal eingelenkt. Schaftglied kräftig, keulenförmig; 1. Gleisselglied kurz oval, von gleicher Stärke wie das Schaftglied, die nächsten Glieder viel schwächer; 2., 3. und 5. Glied länger als breit, etwas kürzer als das 1. Glied; 4. Glied wenig länger als breit; 6. und 7. Glied so lang wie breit. Erstes Glied der Fühlerkeule etwas länger als breit; 2. und 3. Glied etwas breiter als lang, das Endglied kurz, zugespitzt. Halsschild breiter als lang, konisch, seitlich leicht gerundet, zum Vorderrand wenig mehr zugerundet, vor

dem Hinterrand mit subbasaler Querfurche; die Querriefen kräftig und dicht, die Punkte in denselben mässig deutlich. Flügeldecken etwa anderthalbmal so lang wie breit, parallelseitig; Punktstreifen mässig stark; Zwischenräume flach, etwas breiter als die Streifen, fein und dicht versetzt zweireihig punktiert. Pygidium fein und dicht punktiert; Abdomen seitlich etwas dichter, Mittel- und Hinterbrust mit Seitenteilen kräftig und sehr dicht punktiert. Vordertibien aussen nur leicht gebogen, innen seicht s-förmig geschweift; Tarsen schlank und dünn.

Weibchen.—Die drei ersten Abdominalsegmente mit je einer Doppelreihe Querbürsten, das 4. Segment mit einer einfachen Querbürste; die Vordertibien etwas kürzer als beim Männchen sonst in der Form aber kaum abweichend.

Färbung metallischgrün, bisweilen mit kupfernem Schein. Länge 2.8 bis 3 mm.

INDIEN, United Provinces, Garhwal, Dudhatoli, in 9,000 Fuss Höhe (*H. G. Champion*), Juni 1920; Süd-Garhwal, Kumaon, in 6,500 Fuss Höhe. British Museum (Natural History); in meiner Sammlung.

Die Art wurde auf Beate kharsu gefunden. Sie ist leicht kenntlich an den seitlich stark gewölbten Augen, die in der grossten Gesamtbreite breiter als der Vorderrand des Halsschilds sind, sowie an den parallelseitigen Flügeldecken. Systematisch steht die Art zwischen *Euops nietneri* Jekel un *bakewelli* Jekel.

EUOPS (CHAROPS) ARMIPES sp. nov.

Augen mässig stark vorgewölbt, Gesamtbreite schmaler als der Vorderrand des Halsschilds. Rüssel kurz, breiter als lang, von der Basis zur Spitze stark verbreitert. Fühler basal eingelenkt; Schaftglied gut anderthalbmal so lang wie breit; 1. Geisselglied kugelförmig; die folgenden Glieder viel schwächer, länger als breit, untereinander in der Länge wenig verschieden; Glieder der Fühlerkeule breiter als lang. Halsschild fast so lang wie breit, seitlich ziemlich kräftig gerundet, die grosste Breite liegt hinter der Mitte; oben kräftig querriefig skulptiert, seitlich stark und sehr dicht runzlig punktiert. Flügeldecken etwas länger als breit, hinter den Schultern leicht eingezogen, dann schwach geradlinig nach hinten verschmälert. Punktstreifen kräftig, nach hinten zu feiner werdend; Zwischenräume nur schmal, leicht gewölbt. Abdomen fein und dicht punktiert, Mittel- und Hinterbrust mit Seitenteilen kräftiger und sehr dicht punktiert. Mitteltibien vor der Spitze aussen mit langem, spitzem, kräftigem Dorn bewehrt.

Färbung schwarz, oben erzglänzend. Länge 2.2 mm.

INDIEN, Lachiwala, Dehra Dun (*H. G. Champion*). British Museum (Natural History).

APODERUS (STRIGAPODERUS) SISSU Mshl.

Apoderus sissu Mshl. ist eine dem *A. picinus* Faust nahe verwandte Art, mit welcher sie den abgeschnürten und aufgeworfenen Halsschildvorderrand gemeinsam hat, von welcher sie jedoch durch folgende Merkmale leicht zu unterscheiden ist: erstens ist der Kopf glänzend und nicht wie bei *picinus* querriefig skulptiert; zweitens sind die Zwischenräume der Punktstreifen auf den Flügeldecken schmaler, mehr gewölbt, glänzender und nicht runzling skulptiert.

Bei der Nominatform sind alle Makeln scharf gezeichnet, bisweilen verbinden sie sich jedoch untereinander und formieren sich zu Querbinden: (*confluens* f. n.), wobei gleichzeitig eine Schwärzung der Mittel- und Hinterbrust, der Seiten des Kopfes und Halsschilds und zuweilen der Spitzen der Tibien und der Tarsen eintritt. Die Flügeldecken können auch mit Ausnahme der Umrandung des Schildchens und her Spitzen der Flügeldecken einfarbig schwarz gefärbt sein, (*modesta* f. n.), oder im Gegensatz dazu das ganze Tier einfarbig rotgelb sein mit Ausnahme von je einer kleinen runden Makel auf der Mitte des 4. Punktstreifens, (*bipunctulata* f. n.).

INDIEN, Kumaon, Haldwani District (*H. G. Champion*), August, 1921. British Museum (Natural History); in meiner Sammlung.

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TRICHOMANES

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SIXTY-ONE PLATES

Trichomanes, as a genus in modern technical descriptive botany, dates from Linnæus, Species Plantarum (1753) 1097. As shown by Underwood, Mem. Torrey Bot. Club 6 (1899) 256, its type is established by reference to earlier works of Linnæus, and is *T. crispum*, an American species belonging to an American group not represented in the Orient. The name goes back at least to Theophrastus and Dioscorides. An account of its history, with guesses at its etymology, is given in the Dissertation of Taschner, presented in Jena in 1843; but these matters do not concern us, because by pre-Linnæan authors, from the ancients to Tournefort, the name was applied to a wholly different fern, *Asplenium Trichomanes* Linn.

The usual, and one may say classic—since it has stood with most authors since the family was recognized—division of Hymenophyllaceæ is into the two genera *Trichomanes* and *Hymenophyllum*. Typically, *Trichomanes* has a tubular involucre and an elongate receptacle; *Hymenophyllum*, a two-valved involucre and included receptacle. Neither of these distinctions is constantly valid. The two genera, however, are phyletic entities, and in but few cases is there reasonable doubt as to the proper assignment of a species. I suspect that several species described as *Trichomanes*, which I have been unable to identify or place, are really *Hymenophyllum;* but the only ones objectively known to me as to which I am in any doubt are in Mettenius' group *Microtrichomanes*, included in this paper, but certainly related to other species universally regarded as *Hymenophyllum*.

Hymenophyllum and *Trichomanes* had doubtless a common ancestry; in other words, the family is a natural one. There

has been, then, in each genus, an element most related to the other; and this was the most primitive element of at least one genus, from which the others (if the genus is monophyletic) have been derived. If such primitive elements survive, they will be recognized. It they do not, it should be possible, with an attainable measure of understanding, to recognize the existing elements nearest to the more primitive extinct ones. This is, of course, the effort of every real student of the group, but I believe that none has yet succeeded; or at any rate, proven his case. Bower, Ferns 2: 248, the last to try, examining the most aberrant species which can be called *Trichomanes*, *T. reniforme*, and one *Hymenophyllum*, *H. dilatatum*, which he misconstrued incomprehensibly, and, electing them as primitive, naturally did not succeed. Many predecessors had made better use of better facilities, without settling the question; and I am one with them.

It is seductively easy to picture the evolution of the family as proceeding from the simplest form to the several groups of larger plants of more complex structure. Let *T. vitiense* be the most primitive, as it really is the simplest known in structure. *Microtrichomanes*, derived from it by the simplest dichotomy of the axes of growth, still without compounding of the frond, is the next step. *Hymenophyllum* proper, and *Leptocionium*, on the one hand, are easily pictured as evolutionary lines from this common source, without a visible break (if attention be held strictly enough to points of resemblance) as wide as we are used to jumping with complacency in all such series. In the other line (that is, *Trichomanes*), the dichotomous or flabellate architecture is maintained, with increasing size and the compounding of the frond, into *Gonocormus*, within which group the branching inevitable with greater size passes from dichotomous through irregular to pinnate. *Didymoglossum*, and thence *Taschneria*, may be derived from *Microtrichomanes;* and all other groups, from *Gonocormus*. I can present a more appealing argument for this scheme than has supported any previous picture of the internal phylogeny of the group; but I do not believe that it represents the facts of the case, even in a broad way.

In the first place, I am satisfied that the minute representatives of every group in which they appear are degenerate in size, not primitive. The smallest of them have undergone reduction until the mere loss of size inevitably involved the loss of characteristics of form and structure, leaving a common

residuum of basic form and structure which necessarily makes them similar, however distinct their ancestry may be. Let a *Trichomanes* or *Hymenophyllum* of almost any group suffer reduction to the stature of *T. vitiense*, and the resulting form must be very much the same; and the loss of structures which could not be supported by so small a frond, and of others which would at best be useless, will hardly fail to result in the structure of that species. The fact that the smallest members of many series are much alike is therefore no evidence that they are primitive.

On the other hand, the Hymenophyllaceæ are ferns, and leptosporangiate ferns, having beyond any question real affinity to other Leptosporangiatæ. It is not in reason to suppose that just those elements of the family—the most minute species, of simplest structure—which are least like other ferns, are the most primitive, by which I mean nearest to the ancestry in common with other ferns. Also, in general, the minute species are local, as compared with *Trichomanes* species in general. And in the cases in which this is not true of species and group—*T. muscoides*, in a broad sense, for instance—there are residual structures which bar any hypothesis of affinity to *Hymenophyllum*. *Microtrichomanes* and *Gonocormus* are of limited, even if broadly limited, distribution; and are most improbably ancestral to the cosmopolitan groups of *T. radicans* and *T. rigidum*.

In my tentative scheme of phylogeny, I construe as the most nearly primitive element of *Trichomanes* the *T. radicans-T. pyxidiferum* group, it being the least specialized, and therein the most similar to *Hymenophyllum*. So far I have convictions or ideas regarding the evolution, from something like this one, of the other groups of *Trichomanes*, these will appear in the course of this treatise, as the characterization of the several groups introduces the appropriate evidence.

There has been the utmost diversity in the position assigned to the family as a whole. Some writers, guided by the simplicity of vegetative structure, have placed it at the bottom of the fern series. Others have assigned these ferns a place near *Davallia*, within the Polypodiaceæ. It is now accepted as a fact that these ferns are Leptosporangiatæ, and generally agreed that within this group they represent an evolutionary line farther advanced than Osmundaceæ, but not so far as Polypodiaceæ, perhaps on a level with Schizaeaceæ and Gleicheniaceæ. As compared with these, however, this family is rich in species, which is evidence of recent evolutionary activity.

Osmundaceæ, Gleicheniaceæ, and Schizaeaceæ (except *Anemia*) are groups with few species of very wide geographical range; which is evidence of considerable geologic age. In the course of this study I have become convinced that *Trichomanes* exhibits the same phenomenon, in a measure not appreciated, and not evident since the general revulsion from the comprehensive species-concept of Hooker and Baker. In these days, a work of this kind results almost always in a considerable increase in the number of species for which recognition is claimed. Christensen's treatise on the American species of *Dryopteris* and my own on *Plagiogyria* and *Calymmodon* are in harmony with the trend of the time. It is not unusual for a monograph to double the number of species in a genus, nor unheard of for it to multiply the number by ten. I describe new species in this treatise, as they are presented by a wealth of material such as nobody has had in hand before; but I leave the genus smaller in number of recognized species than I found it. It is a large and diversified genus, but it contains a considerable number of species which compare in range with the species of *Gleichenia* and *Lygodium.* It is an old genus, as they are old.

The chief explanation of the shrinkage in species has not been the careless redescription of identical plants by my predecessors—which has naturally occurred here, as in other genera. In greater number, species are reduced to synonymy because I have found the species of *Trichomanes* to be plastic, in a measure unknown to me in any other group. Recognizing this condition, I have then recognized the identity in many cases of plants so distinct in appearance that reasonably good descriptions, as such things go, have shown no reason to suspect the identity.

This plasticity or polymorphism is most remarkable in *Gonocormus,* but, less conspicuously, characterizes *Trichomanes* as a whole. Its commonest expression is extreme variability in the size of fertile fronds. It is my impression that among ferns and vascular plants in general, a range in lineal dimensions from 1 to 2 more than suffices to cover any normal or at all common variation in size; that is, if the common limit in length of frond is 20 centimeters, few if any will be found fertile less than 10 centimeters long. A wider range is common in *Trichomanes,* even 1 to 4. Correlated with the variation in size, there must be some, and may be other, modifications. Dwarfs in the group of *T. rigidum* tend to be relatively narrow; in the group of *T. radicans,* relatively broad. A species may be quadripinnatifid in full development, but only bipinnatifid in its dwarf forms.

The segments or pinnules of a dwarf may be narrower, but are surer to be less numerous, than on an ample specimen. Meric distinctions have perhaps had undue prominence in recent descriptive botany; but even when they were formally barred from diagnoses, and presented in supplementary comments if at all, they found expression in other terms. Thus, with the loss in number of coördinate segments a pinnatifid pinnule which is linear with 11 of them becomes ovate if the number falls to 5; trifid, palmate or flabelliform if it falls to 3; furcate or auriculate if it loses another; and simple, with reduction to one. Such differences as these terms denote characterize species in general, in all groups; but a considerable number of invalid *Trichomanes* species owe their publication to failure to recognize these differences as necessary incidents to decrease in stature.

Assign any plant to the wrong genus, and it makes a very distinct new species. The most important part of every description of a species is condensed in the generic name. The description may be accurate and as complete as ought to be necessary, but if the generic name is wrong the plant is likely to be unrecognizable. In *Trichomanes*, assignment to a subgenus or group, or comparison with some species typifying a group, has often been used in substitution for many words of description—and to good purpose, if the assignment was correct; but some authors have had amazingly little understanding of the groups, and even the lysigenists have known them imperfectly. In most of the instances in which I have failed to place a species, it is because the group is not stated, or because I mistrust the statement. In more instances, the examination of authentic specimens has enabled me to locate species which otherwise would have remained pure mysteries.

From 1843, at the latest, when Presl's Hymenophyllaceae appeared and the first volume of Hooker's Species Filicum, including these plants, was prepared, it should have been clear that particular care was demanded in descriptions of these plants; yet no subsequent descriptive botanist has seemed to be guided by this fact, with the single exception of van den Bosch. In particular, the work of Presl and van den Bosch left no chance for reasonable doubt as to the importance of the venation, for the recognition of species and groups, yet this criterion is totally ignored in a large part of the descriptions published since their times.

I have written many treatises on genera of ferns, but have found no other comparable in difficulty with *Trichomanes*. The difficulties which have just been rehearsed—careless, incomplete,

and wrong descriptions—more serious in this than in most genera, and strongly discrepant and discordant treatment by previous specialists in the group, were not the most fundamental trouble. My first attempt at a presentation of the Malay-Asiatic species dates back to 1908. Several years of intermittent effort brought me to the conclusion that no digest and summarization of the literature, such as had served some purpose in my hands with the equally large genus *Cyathea*, and was proving very useful as performed by van Alderwerelt for the ferns as a whole of that region, would have any utility at all in the case of *Trichomanes*. The early difficulty seemed to be that I did not have authentic material of enough species, and could not recognize or conceive them with a measure of objective reality, by description. With some special effort, I accumulated specimens from year to year, trying several times, in vain, to block the work out in a manner to promise eventual success. Not until after twenty years did it become plain that my real, basic difficulty, and that responsible for the measure of failure of my predecessors, was failure to recognize the groups.

Such satisfaction as I take in the presentation of this treatise is based, not on the description of some species as new, and on the reduction to synonymy of a more considerable number, including a fair part of those for which I was previously responsible, but on the feeling that the groups are now correctly segregated, and the hope that, by word and illustration, they are made recognizable by others.

As to the status of these groups, I adopt for the present a conservative attitude, and avoid the occasion of publishing any new names for old species by letting *Trichomanes* remain a very large and diversified genus. Only the most unique species, *Cardiomanes reniforme*, is given separate generic status. Many of the groups are entities as distinct as are many of the genera recognized in Polypodiaceæ; and the maintenance of such a genus as *Trichomanes* does not serve convenience. It should and, eventually or presently, will be broken up. This need not be done in haste, and before I take the step there are several questions to be answered; for instance, what should be included in *Didymoglossum*. Most, perhaps all, of the groups worthy of generic rank have names—some generic, some that can be made generic. *Crepidium* may be the only one usable for a group without formal status but not available for a genus.

My need of twenty-four years for this work will be understood, and the imperfections still manifest and sure to become so will be more readily excused, after a cursory review of the

previous efforts. Monographic treatises on Hymenophyllaceæ have been undertaken by Presl, Hooker (in Species Filicum), van den Bosch, Mettenius, Prantl, and Giesenhagen. Only the first two have, even in form, accomplished their purpose.

Presl, Hymenophyllaceæ (1843), divided the genus, as previously construed by most writers, into two sections, each consisting of a number of genera. Among these genera as represented in our area, only *Cardiomanes* retains that rank in the present treatise. *Cephalomanes, Microgonium* (including *Hemiphlebium*), and *Abrodictyon* are groups susceptible of generic recognition; but his *Didymoglossum* is not so, whatever may be true of the original *Didymoglossum* of Desvaux. In Epimeliae Botanicae (1849), Presl first (pp. 16–21) increased the number of sections left in *Trichomanes;* and then (p. 258) raised *Crepidomanes* and *Pleuromanes* to generic rank with diagnoses, and published without diagnoses *Crepidium, Taschneria, Leucomanes,* and *Amphipterum,* illustrating each by a species. This would be sufficient evidence that Presl was not finished with his treatment of the groups; if not, it may be noted that his *Pleuromanes pallidum* and *Leucomanes album* are one species. As to the species, Presl avowed his work as not near completion.

Hooker paid his compliments to Presl's treatment in such comments as "Than which nothing càn be more at variance with nature." But he fared no better himself; for Kuntze, in a review running through many numbers of the Botanische Zeitung (1847), subjected his treatment, species by species, to a criticism so competent that we must regret that he, instead of Presl and Hooker, did not undertake a systematic presentation of the genus.

Van den Bosch, a physician by profession, presented the Hymenophyllacae Javanicae (1861), carefully described and beautifully illustrated. Fascinated by these plants, he took up the task of monographing the order, and as a preliminary published a Synopsis (1859), listing and arranging the species known to him. In 1861 and 1863, he published as supplements to the Synopsis numerous new species, which were based in large part on specimens in the Hooker herbarium, and which Hooker, Synopsis Filicum (1867), promptly refused to recognize. In all of these works there was a rough approximation to Presl's classification; but at the same time he published an outline [1] of his own proposed classification of the order. As this remains even

[1] Eerste Bijdrage tot de Kennis der Hymenophyllaceae, Versl. in Meded. d. Koninkl. Akad. van Wetenschappen. Afb. Natuurk. 11 (1861) 300–330.

to-day the most competently prepared complete outline, it is here reproduced, in full as to the subjects of my own study and in outline as to other subjects.

Suborder 1. HYMENOPHYLLACEAE. Lamina 1 cell thick.
  Tribe 1. HYMENOPHYLLEAE. Two genera.
  Tribe 2. LEPTOCIONIEAE. Three genera.
  Tribe 3. TRICHOMANEAE. Indusium tubular.
    A. Lip of indusium bilabiate.
      Hemiphlebium Presl.
      Didymoglossum Desv.
    B. Lip of indusium undivided.
      a. False veinlets present.
        Microgonium Presl.
        Crepidomanes Presl.
        Lacostea v. d. Bosch.
      b. False veinlets wanting.
        Venation catadromic. Four American genera.
        Venation anadromic.
          Cephalomanes Presl.
          Phlebiophyllum v. d. Bosch.
          Habrodictyon Presl.
          Gonocormus v. d. Bosch.
          Trichomanes Linn.

Suborder 2. DIPLOOPHYLLACEAE.
  Cardiomanes Presl.
  Craspedoneuron v. d. Bosch.
  Three American genera.

Suborder 3. LOXSOMACEAE.
  Loxsoma.

It may be noted here that the genera of his predecessors were handled very freely by van den Bosch. *Didymoglossum* of Desvaux, for example, would have included *Hemiphlebium*, but the *Didymoglossum* of van den Bosch is substantially Presl's *Taschneria*. *Crepidomanes* of van den Bosch includes and is typified by *Crepidium* of Presl. *Craspedoneuron* is Presl's *Pleuromanes* and *Leucomanes*.

At this point, death denied Doctor van den Bosch the opportunity to complete his study. A half-century later, some of his notes were published.[2] Mettenius,[3] Prantl,[4] and Giesenhagen,[5] all avowedly undertook to monograph the family, and all began with an anatomical study, yielding information wanted for the

[2] Meded. van s'Rijks Herbarium No. 17 (1913); No. 38 (1919).

[3] Ueber die Hymenophyllaceae. Abhandl. Sächs. Ges. Wiss. 7 (1865) 401–504; 5 plates.

[4] Die Hymenophyllaceen (1875).

[5] Die Hymenophyllaceen. Flora 73 (1890) 411.

eventual classification of the plants. Only Prantl reached the point of presenting the outline of a scheme of classification, and he did not carry this beyond the use of a fraction of the known species, to illustrate his genera and sections. In outline, including the most of the Oriental species listed, Prantl's classification, Die Hymenophyllaceen (1875) 45–53, is as follows:

Tribus I. TRICHOMANOIDEAE.
- Fam. 1. CARDIOMANEAE.
  - 1. *Cardiomanes: C. reniforme* (Forst.) Presl.
- Fam. 2. PTILOPHYLLEAE.
  - 2. *Hemiphlebium* Presl emend.
    - Sect. 1. *Microgonium: H. sublimbatum, Motleyi* and *cuspidatum* (& American).
    - Sect. 2. *Hemiphlebium* Presl em. VDB. all American.
    - Sect. 3. *Lecanium* Presl, VDB.: *H. membranaceum*, American.
  - 3. *Ptilophyllum* VDB. emend. all American.
  - 4. *Lacostea* VDB. em.
    - Sect. 1. *Lacostea* VDB. em. American.
    - Sect. 2. *Cephalomanes* [as I construe it].
- Fam. 3. TRICHOMANEAE.
  - 5. *Gonocormus* VDB. em.
    - Sect. 1. *Gonocormus* VDB. 4 spp. Javanicae.
    - Sect. 2. *Microtrichomanes* Mett. 5 spp. orientales.
  - 6. *Trichomanes* L. em.
    - A. Minora.
      - Sect. 1. *Crepidomanes* Presl em.: *T. humile, schmidianum, intramarginale,* & 2 American.
      - Sect. 2. *Didymoglossum* Presl em.: *T. Filicula, capillatum, bilabiatum.*
      - Sect. 3. *Craspedoneuron* VDB.: *T. album, pallidum, Braunii, glaucofuscum.*
      - Sect. 4. *Phlebiophyllum: T. venosum.*
    - B. Majora.
      - Sect. 5. *Leptomanes:* Amer. exc. *T. Smithii* (*Abrodictyum Cumingii* Presl).
      - Sect. 6. *Eutrichomanes: T. speciosum, maximum, longisetum, apiifolium,* & American.
      - Sect. 7. *Lacosteopsis:* Amer. incl. *T. radicans.*
      - Sect. 8. *Selenodesmium: T. rigidum, obscurum, elongatum.*
      - Sect. 9. *Davalliopsis:* American.

TRIBUS II. HYMENOPHYLLOIDEAE.
- 7. *Hymenophyllum*, in 4 sections.

Even more than van den Bosch, Prantl changed the use of the older generic names.

There have been two more-recent enumerations of the species. Sadebeck [6] began, like Prantl, with the species with simple fronds, but did not apparently attempt to classify the species for any other purpose than facility of identification. The same is true of the Malayan Ferns of van Alderwerelt van Rosenburg. In both of these works, the minor genera of Presl, van den Bosch, etc., are abandoned or reduced to the status of sections. At least for the present this is my policy also.

While intending this treatise to serve as a monograph for the group and region treated, I have fallen particularly far short of the mark as to the western part of the area—Africa and its islands. I would have preferred to restrict myself to the Malay-Asiatic floristic region, but was forced to take account of the African islands, because some of the species most critically important in the Malay region were described there. Being thus compelled to deal with these species and islands, I have thought it expedient to treat the African species, so far as material was available. However, my presentation of the African species has had to remain so incomplete that I have abstained from even the mention of species not seen—except and unless these species have at some time been reported farther East.

I have deliberately deviated from modern monographic practice—a practice for which the model was established for all time by Milde's treatise on *Equisetum*—by abstaining from the citation of literature and of collections, except as the citation could be expected to be of service to some other worker. The listing, as citations of literature, of every published mention of a species or of its name has become a silly waste of space. As exemplified in many recent treatises, the lists of publications have no necessary relation to the plant, but only to its name; and the compilers of such lists usually have and can have no idea as to whether the plant or merely its name is referred to. I would have added not less than one-third to the bulk of this publication by complete citations of this kind. Brause lists, for example, fifty-one species of *Trichomanes* from Papua. The mere citations, one at a time, would occupy perhaps a page. In a case like *T. acroscopum,* the citation would serve no purpose because he merely refers to another publication; in such cases, though, one is at least sure of the plant in question. In a case like *T. bipunctatum,* even that much is not certain; I

[6] Natürlichen Pflanzenfamilien of Engler and Prantl 1 pt. 4 (1902).

doubt its occurrence in Papua, but may not presume to correct Brause's list without seeing all the specimens on which it was based—an impossibility which is patent when it is considered that the list is partly original and partly founded in turn on mere report.

Even in devoting space to the listing of synonyms I have been abstemious—possibly too much so in this case. Pteridologists have in Christensen's Index Filicum the most perfect compilation of synonyms ever compiled for any large group of plants, and make poor use of it if it is used to facilitate instead of to obviate the padding of our literature with lists of this kind.

I have listed collections only when there was an evident service to be performed by the citation—types, of course; other specimens authenticated by the author or by comparison with the type; specimens peculiar enough to require detailed mention; specimens substantiating statements as to range, when this seemed necessary; specimens distributed wrongly named; some doubtful cases; and the subjects of my illustrations, to permit appraisal of their authenticity. The enumeration under each common species of every collection seen, and of the herbaria in which it is represented, impresses me as a waste of space. It has been incumbent upon me to examine several hundred specimens of some of these species, which is bad enough without the publication of the details. The time approaches when such enumeration will be impossible; as herbaria multiply and grow, the subject of a volume would have to be one species, instead of a genus or family.

An index of collections, arranged by collectors and their collection numbers, in sharp contrast with an enumeration of collections arranged by species, would be of real utility in the application of names to herbarium specimens, and the impossibility of compiling such an index is regretted.

The distribution of the species of *Trichomanes* is remarkably uniform. Statistics as to the number of species in different geographical regions are, of course, subject to distortion incidental to the selection of the areas and the interpretation of the species. Construing the species as I have done, and dealing only with those which I list with numbers, Polynesia (including Hawaii but not New Zealand nor New Caledonia) has 30; Asia excluding the Malay Peninsula, 20; Papua, 27; the Philippines, 27; Java, 24. Africa, including its islands, would fall within this range if I had been able to treat it with the same thoroughness. These figures illustrate the subjective nature of

such statements, being too low for Asia, because of my summary treatment of *Taschneria,* and too high for Java, because of maintenance of disproportionally many species of *Gonocormus.* Still, whatever allowance may be made for my inconsistencies and mistakes, it remains true that the distribution is strikingly uniform.

The wide distribution of the most of the groups is also noteworthy. Only two of the groups—and these the only monotypic groups, *Abrodictyum* in the Philippines, and *Phlebiophyllum* in New Zealand—are local. *Crepidium* and *Pleuromanes* range from Asia across Polynesia. *Microtrichomanes, Gonocormus, Taschneria, Macroglena,* and *Cephalomanes* range from Polynesia west at least to the East African Islands. The groups of *T. pyxidiferum, T. radicans,* and *T. rigidum,* and *Hemiphlebium* are pantropic or world-wide.

Beside the facilities of the University of California and of my own herbarium, I have had loaned for a long period the specimens subject of this study from the United States National Herbarium, the Gray Herbarium, and the herbaria of the Bureau of Science in Manila, the Singapore Botanic Garden, and the California Academy of Science. After the University of California contributed more than 800 dollars to the illustration of this study, the National Research Council made possible its completion by a grant of 500 dollars. To all of these institutions and to their chiefs and to those inconvenienced by my calls and my delays, I tender this expression of very sincere gratitude. To Dr. W. R. Maxon, Dr. E. D. Merrill, Dr. Carl Christensen, Dr. H. L. Lyon, and Count Ugolino Martelli, I am indebted for assistance in details.

All photographs have been made by Mr. W. C. Matthews, whose work speaks competently for itself. The drawing was done at first by Miss Alice Hamilton; the illustrations of *T. dentatum* and *T. caudatum* are examples of her work. Miss Phyllis Wrightson then assisted me for nearly a year, and is entitled to the largest part of the credit for the artistic quality of the drawings. This phase of the work was completed by Dr. H. S. Yates, to whom I am indebted for much technical judgment as well as for quickness and accuracy. Plate 1, fig. 2, is the work of W. Garcia. Good illustration is of such exceptional importance in a treatise on *Trichomanes* that the obligation to the artists deserves particular emphasis. For the composition of the most of the plates, I am indebted to the Bureau of Science and, particularly, to Dr. Eduardo Quisumbing.

Finally, being called away for work of another kind as this study approaches completion, I entrust the final details of preparation for the press to Dr. H. F. Copeland, in charge ad interim of the herbarium of the University of California.

List of the groups.

1. Pyxidifera.
2. Phlebiophyllum.
3. Pleuromanes.
4. Gonocormus.
5. Microtrichomanes.
6. Crepidium.
7. Taschneria.
8. Hemiphlebium.
9. Scandentia.
10. Grandia.
11. Apiifolia.
12. Rigida.
13. Cephalomanes.
14. Abrodictyum.
15. Macroglena.

Key to the groups.

Rhizome creeping, filiform.
- Fronds simple or lobed .... 8. *Hemiphlebium.*
- Fronds dichotomous or palmate, never proliferous. 5. *Microtrichomanes.*
- Fronds dichotomous to pinnate in plan, some axes proliferous. 4. *Gonocormus.*
- Fronds pinnate in plan, not proliferous.
  - Without false veins or specialized margin.
    - Segments with costa only .... 1. *Pyxidifera.*
    - Not dissected into segments with single veins. 2. *Phlebiophyllum.*
  - Margins specialized, without other false veinlets.
    - Broad, thick axial pads present .... 3. *Pleuromanes.*
    - Without broad axial pads .... 6. *Crepidium.*
  - Spurious veinlets present .... 7. *Taschneria.*

Rhizome stout and/or fronds clustered.
- Fronds simply pinnate, stipes clustered .... 13. *Cephalomanes.*
- Fronds more compound, or stipes remote.
  - Fronds dissected into almost bristlelike segments. 15. *Macroglena.*
  - Segments broader, or soft.
    - Rhizome elongate, fronds remote .... 9. *Scandentia.*
    - Rhizome shorter, erect, fronds clustered.
      - Cell walls not thickened and pitted.
        - Epiphytes with large, tender fronds .... 11. *Apiifolia.*
        - Terrestrial, with firm fronds .... 10. *Grandia.*
      - Cell walls thickened and pitted.
        - Cells elongate transversely to costa .... 14. *Abrodictyum.*
        - Cells not elongate transversely to costa .... 12. *Rigida.*

I. THE GROUP OF TRICHOMANES PYXIDIFERUM

Small ferns, with creeping, filiform rhizomes, pinnatifid or more compound fronds, and no false veins or specialized margins. The species assembled here are not altogether a natural

group. The most of them, with the group of *T. radicans,* really constitute one group, which is the least-specialized element of the genus, and on this ground susceptible of construction as its most primitive element. From the group here treated, taking it in a generalized sense, have probably been derived *Crepidium, Gonocormus, Pleuromanes, Phlebiophyllum,* and *Taschneria.* Tropics of both hemispheres.

Key to the species.

Involucre not bilabiate, or but slightly so.
  Rachis winged.
    Sori axillary.
      Involucre narrowly winged.
        Mouth entire.
          Frond commonly 5 cm long........ 1. *T. pyxidiferum.*
          Frond less than 3 cm long.................... 3. *T. parvum.*
        Mouth dentate .... 4. *T. draytonianum.*
      Involucre broadly winged.
        Frond lanceolate to oblong......................... 9. *T. latifrons.*
        Frond commonly ovate............................ 5. *T. schmidianum.*
    Sori terminal on major segments........................ 2. *T. stenosiphon.*
  Rachis wingless .... 7. *T. Colensoi.*
Involucre strongly bilabiate .... 6. *T. Hosei.*

1. TRICHOMANES PYXIDIFERUM Linnæus. Plate 1, fig. 1.

Trichomanes pyxidiferum LINNÆUS, Sp. Pl. (1753) 1098.

Trichomanes frondibus sub-bipinnatis; pinnis alternis confertis lobatis linearibus.

Filix pyxidifera *Plum. fil. 74. t. 50. t. B.*

* * * * * * *

Habitat in America.—Linnæus, loc. cit.

Rhizome creeping, filiform, densely beset with black hairs; stipes remote, 2 to 3 cm long, terete, with a narrow wing on the upper part; frond up to 8 cm long and 3.5 cm wide, 5 by 2 cm being a commoner size, bi-tripinnatifid; rachis winged; segments less than 1 mm wide, short, green; marginal walls thin, lateral walls moderately thick but appearing more so because of the contents appressed to them, straight, uniform; sori occupying short lower segments, involucre 2 mm long, winged, with dilated mouth, not or hardly bilabiate, receptacle protruding by twice the length of the involucre. The sorus illustrated, Plate 1, fig. 1, is atypical, having the tube wider, and the mouth less dilated than usual.

Natal, *Wood, s. n.* Kilimanjaro, *Daubenberger 32.* Usambara, *Holst 1243.* Also in the American Tropics.

Fehse 15, from Kamerun, has sori occupying all segments near the apex of the frond. *Last 349,* from eastern tropical Africa, has the mouth more overfull, and therewith somewhat bilabiate. A Natal specimen, *Buchanan 1, U. S. Nat. Herb. 827161,* has the involucre very narrowly winged, rather short, and truncate. All of these can be *T. pyxidiferum,* without removing all bounds to the species. *Staudt 454,* distributed as *T. erosum,* which it is not, may also be a small form of it, and is at any rate a relative.

On the other hand, no one of the very many Asiatic and Malayan specimens found bearing this name may well be so construed. In about equal numbers, the most of them are either *Gonocormus,* or relatives of *T. bipunctatum,* with false veins.

Trichomanes pyxidiferum and *T. radicans* are related, and no wide gap separates the smaller plants referred to the latter species from strong specimens of *T. pyxidiferum.* *Trichomanes pyxidiferum* as a group, not in this connection as a species, is reasonably to be construed as parental to *Pleuromanes,* to *Gonocormus,* and to *Crepidium;* and I believe that the same ancestry may reasonably be postulated for *Taschneria.*

2. TRICHOMANES STENOSIPHON Christ. Plate 1, fig. 2.

Trichomanes stenosiphon CHRIST, Fedde's Repert. 5 (1908) 10.

Rhizomate tenui, intricato, longe repente, more *Hymenophyllorum* intertexto, ramosissimo, radicoso. Foliis numerosis approximatis, stipite 1 ad 3 cm longo alato, fronde 3 ad 5 cm longa, ovata acuminata aut rotundata, ad basin haud attenuata, tripinnatifida, rachiolata [rhachi alata] undulata, pinnis alternis patentibus, confertis, ovatis, infimis deltoideis, costis costulisque alatis, pinnulis ovato-cuneatis, iterum fere flabellatim dissectis, lobis ultimis 1 mm latis, furcatis, subacutis, saepe valde divaricatis, nervo uno conspicuo praeditis, urceolis terminalibus 1½ mm longis, ⅔ mm latis, cylindricis, raro subcampanulatis, vix aut ne vix quidem latioribus quam lobi soriferi; ore vix dilatato, receptaculo exserto, textura subcoriacea diaphana; colore atrobrunneo.

Corea: in lacunis torrentium, Quelpaert, Oct. 1906, No. 108 (Urb. Faurie leg.).—Christ, loc. cit.

My specimen of *Faurie 108* is almost sterile, but *106* of the same collection is the same species and fits the description completely. *Faurie 124* of 1906 and *56* of 1907 are probably not specifically different, but have broader indusia, those of *124* more evidently bilabiate.

The crisping of the wing of the rachis, in a manner suggesting *Hymenophyllum australe,* is very evident on *Faurie 106,*

108, and *56*. The position of the sori, immersed in the apices of the major segments, is notable in the group; and the involucres, especially those of *106*, when observed dry, well justify the specific name.

Known from Korea only. Like *T. parvum*, a reduced member of the group of *T. radicans*. I do not know that it is not *T. amabile* Nakai, which, by description, I have reduced to *T. radicans*.

3. **TRICHOMANES PARVUM** Copeland sp. nov. Plate 1, fig. 3.

T. parvum gregis T. radicantis, rhizomate filiforme nigrohirsuto; stipitibus setiformibus 1 ad 2 mm longis deinde 1 cm longis ad latitudinem 1 ad 1.5 mm alatis; fronde 2.5 ad 3 cm alta, 1.5 cm lata, bipinnatifida segmentis interdum apice fissis, rhachi late alata; pinnis (accuratius segmentis primae ordinis) paucis, late ovatis, flabellatim pinnatifidis; parietibus cellularum tenuibus, ob interanea aspectu crassioribus; venis spuriis omnino carentibus; soris axialibus acroscopicis, sessilibus, parvis, involucro vix ultra 1 mm longo, infundifuliforme, alato, ore leviter dilatato non bilabiato, receptaculo exserto.

Formosa, Tamsui Mountains, "damp rocks in dark glens—very rare." *W. Hancock 107*, September 4, 1881. Type, *U. S. Nat. Herb. 51140*. Only one of the many fronds of this specimen is fertile.

As occurs with other small species, the imperfectly or atypically developed fronds are of all possible shapes. The winged stipes mark this dwarf clearly as no *Gonocormus;* these, with the black, densely hairy rhizomes, the texture, and the sori, let it be recognized as a relative of *T. radicans*, the most reduced known. It cannot be identified with *T. Kurzii* (assuming identity with *T. nanum* van den Bosch), nor with *T. acuto-obtusum* Hayata, because of the absence of false veins. It is distinguished from its relative, *T. stenosiphon*, by the position of the sori, the broad wing on the stipe, and the noncrisped wing of the rachis; as the two are known, it is distinctly smaller.

4. **TRICHOMANES DRAYTONIANUM** Brackenridge. Plate 1, figs. 4 to 7.

> *Trichomanes draytonianum* BRACKENRIDGE, U. S. Expl. Exped. 16 (1854) 252, pl. 36, fig. 3.

HAB. Sandwich Islands; in humid forests, creeping over the trunks of trees.

Rootstock creeping and *pubescent*, stout in proportion to the size of the fronds; the rootlets *tomentose* with a dense coating of short black hairs. *Stipe flattened*, about half an inch in length, smooth, with a narrow mar-

gin, which increases in breadth towards the base of the frond. *Fronds broad-lanceolate,* glabrous, 2 inches and upwards in length, by 8 to 10 lines broad, of a pale green colour, deeply *bipinnatifid* at the base; the *primary divisions* somewhat rhombic-*ovate* and less deeply divided: *laciniae short, nearly oblong, obtuse, simple,* or else *bifid* or bidentate. Rhachis and veins stout of a dull-brown colour. *Indusium supra-axillary, subcylindrical, immersed, about half its length, attenuated at the base,, the mouth spreading, scarcely two-lipped,* its diameter nearly equal to the length; the wings on the outer side sometimes wanting. *Receptacle filiform, exserted* about twice the length of the indusium.

Related to the preceding species [*T. humile*]; but readily distinguished by its only partially immersed indusium, with a more spreading mouth, and by the absence of a thickened margin to the frond.

Brackenridge's descriptions of new species are provided with brief Latin diagnoses, but the English versions are the more authoritative as well as the more complete.

Brackenridge collected this species on Oahu and Hawaii; I have it also from Kauai, Molokai, and Maui. It has been distributed under its proper name, as *T. humile,* and as *T. Filicula.* To the last (*T. bipunctatum*), it has no near affinity. There is more resemblance to *T. humile.* If this is evidence of affinity, *T. draytonianum,* confined as it is to the Hawaiian Archipelago, which has certainly derived the greater part of its fern flora from the South Seas, is to be regarded as a derivative of *Crepidium,* which has lost the distinctive character of that group of species.

Aside from the absence of the specialized margin, it is distinguished by a more-expanded lip, with shallowly sinuate-dentate margin; by less-dissected primary segments (pinnæ), giving the frond a more compact appearance; by the occasional absence of a wing near the base of larger fronds, which are then really pinnate; and by the presence on such fronds of two or three sori on the larger primary segments. I do not find on Brackenridge's material, nor on any other, any sori which are not winged throughout; the wing is very variable, sometimes wider than I have ever seen in *T. humile.* The mouth is not bilabiate, but is so dilated that it is almost always made to appear so when pressed.

5. TRICHOMANES SCHMIDIANUM Zenker. Plate 2, fig. 1.

T. Schmidianum ZENKER ex Taschner, Dissert. (1843) 34, pl. 1, figs. 1, 3, 5.

Tr. fronde bipinnatifida, ovato-oblonga; rhachi alato sinubus subrotundis; lobis oblongis obtusis, pinnatifidis, decurrentibus; laciniis bi-trifidis subretusis, margine integro, nervis stipiteque squamoso-hirsutulis; in-

volucris axillaribus, exsertis, infundibuliformibus, subpedicellatis, margine subundulatis. Columella subhirsuta, involucro longe prominente apice brevi.

Observ. Planta junioribus Trich. pyxidiferi L. exemplaribus affinis, differt vero structura graciliori involucris excavatis, patentissimis, infundibuliformibus, margine subundulatis. . . . Frondes tripollicares, 1–1½ pollices latae, virides . . . .

Crescit in India oriental. Montibus coeruleis Outacamund, . . .—Taschner, loc. cit.

In the Gray Herbarium is a specimen from the Hooker collection, collected by Schmid, fitting this description in everything except size; this may well be a cotype. The involucre is slightly longer than as depicted by Taschner; and I do not find the trichomes present on his figures, but these might well have disappeared with time. The fronds of this specimen are 3 cm, rather than 3 inches in length.

This is the fern figured as *T. Filicula* by Beddome, Ferns of Southern India, Plate 7, later corrected (with Plate 283 of Ferns of British India) to *T. pyxidiferum,* with notation that it is "the *Schmidianum* of Van den Bosch." It falls within the range of the plants called *T. pyxidiferum* in America, but can be distinguished from what I suppose to be that species in a stricter sense by relatively short involucre, with less-dilated mouth and broader wing. I have seen only the one specimen.

Besides the foregoing species, there have been described many either said to be relatives of *T. pyxidiferum* or appearing from the descriptions to be such. I have found the alleged relatives, when known to me by specimens, to belong in various groups, most often in *Gonocormus* or *Taschneria.* Because false veins are critically important in the recognition of groups, but are still often ignored in descriptions, nothing remains but to assume affinity, until specimens are seen. In this manner, I provisionally assign to this group the following three species:

TRICHOMANES MICROCHILUM Baker.

T. microchilum BAKER, Trans. Linn. Soc. Bot. 4 (1894) 250.

Collected at 7,000 feet altitude on Mount Kinabalu, Borneo, *Haviland 1478.* By description, this seems suspiciously like its coendemic, *T. Hosei,* described seven years earlier by the same author.

TRICHOMANES WILDII Bailey.

T. Wildii BAILEY, Queensland Dept. Agr. Bot. Bull. 4 (1891) 19, pl. 5a; Lithograms, Ferns of Queensland 22.

Rhizome slender, tomentose, forming dense masses on bark. Fronds including stipes about 1 in. high, pinnate, with pinnatifid pinnae, stipes

flattened as in *T. Barnardiana*, with a few dark hairs at the very base. Pinnae few, distant, with 3 or 4 linear lobes, veinless except the central costa. Indusium almost free on the upper side of the pinnae some distance from the axil, mouth spreading but scarcely lipped.

Hab.: near Cairns, *C. J. Wild.*—Bailey, loc. cit.

Apparently a distinct species, with some resemblance to *T. draytonianum.*

TRICHOMANES HIERONYMI Brause.

T. Hieronymi BRAUSE, Bot. Jahrb. 49 (1912) 6.

Northeast New Guinea, *Schlechter 19701.* Said to resemble *T. brevipes* in appearance, but to have toothed margin of segments and involucres, no false veins, and wingless stipes. Toothed margins are strongly suggestive of *Leptocionium.*

6. **TRICHOMANES HOSEI** Baker. Plate 2, figs. 2 to 4.

Trichomanes Hosei BAKER, Journ. Linn. Soc. Bot. 22 (1887) 223, pl. 12.

Rhizomate filiformi late repente, stipite brevi nudo haud alato, frondibus parvis ovato-rhomboideis tripinnatis, pinnis inferioribus maximis deltoideis basi postice cuneato-truncatis, segmentis ultimis linearibus uninerviis integris ascendentibus, soris terminalibus solitariis, involucro infundibulari angusto alato labiis 2 parvis semiorbicularibus praedito, receptaculo breviter exserto. (Plate XII.)

A small finely-cut species allied to the Philippine *T. brevipes*, Baker, and *T. Smithii*, Hook., and Polynesian *T. tenue*, Brack. Fronds about 2 inches long, ½ inch stipe included, erect, spaced out upon the long filiform rhizome. Final one-nerved entire segments about ⅓ of a line broad, not more than ⅛–⅙ in. long. Involucre ⅛ in. long, narrowly winged on both sides nearly or quite to the top of the tube.—Baker, loc. cit.

Known to me by a cotype in the Singapore Herbarium. It might well constitute a group by itself, having the involucre of a *Tachneria* but no false veinlets, and cell walls suggestive of *T. cupressoides.*

7. **TRICHOMANES COLENSOI** Hooker, f. Plate 3.

Trichomanes Colensoi HOOKER, F., Ic. Pl. 10 (1854) 979.

Caudice gracili filiformi elongato, frondibus oblongis acuminatis laxe pinnatis, pinnis subpinnatifidis laciniis brevibus linearibus angustis acutis erecto-patentibus integris vel incisis, involucris solitariis basin versus singulae pinnae insertis infundibuliformibus stipitatis liberis, columella longissime exserta flexuosa.

Trichomanes Colensoi, *Hook, fil, mst.*

HAB. Interior of the Northern Islands, New Zealand, near Waikare Lake, *Rev. W. Colenso, n. 104.*—Hooker, loc. cit.

Stipes remote, 2 to 3 cm long, filiform, wingless; fronds commonly 8 cm long and 2.5 to 3 cm wide, bipinnate, with filiform,

wingless, sometimes zigzag or flexuous rachis; pinnules stalked; cuneate, incised with erecto-patent segments, thin and green; walls thin, straight, uniform; sori in the place of the lowest acropetal pinnules, or less frequently of basal acropetal segments, involucre narrowly winged, truncate. Plate 3, fig. 1, frond, × 1; fig. 2, detail of structure, × 400; fig. 3, sorus, × 15; the sori are often more slender.

New Zealand, both islands, endemic.

2. PHLEBIOPHYLLUM; THE MONOTYPIC GROUP OF T. VENOSUM

8. TRICHOMANES VENOSUM R. Brown.

Trichomanes venosum R. BROWN, Prod. Florae N. Holl. (1810) 159; HOOKER and GREVILLE, Ic. Fil. pl. 78; FIELD, Ferns of New Zealand 71, pl. 14, fig. 4; pl. 18, fig. 3.

Frondibus pinnatis, pinnis linearibus venosis crenato-repandis: inferioribus basi lobatis v. pinnatifidis intusque unifloris. (D. J.). *v. v.*—Brown, loc. cit. [J signifies Port Jackson; and D, Tasmania.]

An epiphyte on trunks of *Dicksonia*, or on mossy logs, etc., rhizome coarsely filiform, 0.3 mm in diameter, dark, hairy; stipes seriate but approximate, 1 to 3 cm long; frond commonly 4 to 6 cm long, lanceolate to obovate or broadly elliptic, pinnate with wingless rachis; pinnæ most variable, ranging on single fronds from ovate and 1 cm long to linear, 3 cm long by 2 mm wide, the lowest short-stalked, the upper adnate, the lower ones commonly with a basal acropetal lobe, membranaceous, glabrous; costa flexuose, veins forked, sometimes twice, or in broad pinnæ several times, without false veinlets or specialized margin; sorus one on a pinna, on the upper side at the base, the tubular involucre commonly half-immersed, the upper half winged, mouth strongly dilated, receptacle long-exserted. With pinnæ of the short form only, this is *T. venustulum* Colenso.

An isolated species, with some affinity to the group of *T. pyxidiferum*, and to American rather than to the Oriental representatives of the group. As a component of the vegetation, it occupies the place taken by *T. pallidum* in the Malay region.

Apparently common in New Zealand and Tasmania, and eastern Australia north to Queensland.

3. PLEUROMANES; THE GROUP OF TRICHOMANES PALLIDUM

A group characterized in its full and typical development by a pad of tissue several cells thick inclosing the costa and extending more or less of the way to the margin; by the presence of long, white hairs on this pad; by glaucescence, sometimes

sufficient to color the frond white or blue; and by a specialized margin, the cells of which are not essentially elongate, nor with very oblique walls. Epiphytes on trunks or rocks, usually with long, weak stipes, the fronds pendent and forming mats. From the Himalayas across Polynesia.

Key to the species.

Axial pad wanting .... 9. *T. latifrons.*
Axial pad narrow, frond naked or nearly so .... 10. *T. acutum.*
Axial pad evident, frond commonly hairy .... 11. *T. pallidum.*

9. TRICHOMANES LATIFRONS van den Bosch. Plate 4.

T. latifrons VAN DEN BOSCH, Ned. Kruid. Arch. 5[3] (1863) 209.
T. cupressifolium HAYATA, Ic. Pl. Formos. 4 (1914) 136, fig. 73.

Fronde oblonga vel lanceolata acuminata bipinnatifida; laciniis primariis erecto-patulis remotiusculis anguste oblongis pinnatifidis, secundariis (lacinulis) erecto-patulis remotis subsimplicibus late linearibus parum elongatis, apice angustato rotundato, margine leviter undulato; rhachi alâ lata undulata deorsum angustatâ marginata venisque et venulis concoloribus; cellulis diaphanis teneriusculis mediocribus (facile magnis) inaequalibus subregularibus elongato-hexaëdris acutangulis, parietibus hyalinis rectis tenuibus, interaneis globulosis, globulis diffusis minutissimis glomeratis densiusculis pallide flavescentibus, marginalibus semi-hexaëdris elongatis, soris majusculis in laciniis secundariis parumper abbreviatis immersis, indusio ventricoso utrinque ala lata undulata marginato in limbum patulum undulatum sensim leviter expanso, receptaculo parum (?) elongato; stipite 2–3 centim. longo apice angustissime alato vel terete concolore. Rhizoma horizontale setaceum parce ramosum atro-fusco-tomentosum; frons 1 decim. circiter longa, 3 fere centim. lata membranacea teneriuscula diaphana fuscidula.

Habitus quaedam intercedit cum *T. glaucofusco* HOOK. similitudo, attentius vero comparatum mox pluribus notis distinctum esse patet nostrum, v. g. limbi opaci juxta venas venulasque, pilorum, glaucedinis defectu, etc.
Hab. India orientalis (Khasya),-? (Herb. HOOK.)—Van den Bosch.

This resembles not the real *T. glaucofuscum* Hooker (*T. pallidum* Blume), but the Philippine plant, *T. acutum* Presl. To the latter it has both resemblance and affinity, but is distinguished, beside in a measure by the points noticed by van den Bosch, by the absence of any marginal line.

Several specimens in the United States National Herbarium and Gray Herbarium, collected by Hooker and Thomson in Khasya, and sent from Kew as *T. gracile* Moore (it does not seem to be *T. gracile* van den Bosch), represent this species. There is also in the Gray Herbarium a specimen from Bhotan, *ex* herb. Griffith, from Kew; as this is named *T. latifrons,* in spite of the fact that the species was not recognized by Hooker and Baker, I suspect that it is a cotype. These are identical

with *Faurie 306* and *625,* from Mount Arisan, Formosa, the type locality of *T. cupressifolium,* which they surely represent. *For. Bur. 16318 Curran, Merritt, and Zschokke,* from Mount Pulog, Luzon, which I marked as new when it was collected in 1909, is also this species.

Hancock 138, from Yunnan, distributed as *T. pyxidiferum,* is thinner and has a narrowly winged involucre; it is near to this species, if not identical.

Trichomanes latifrons and *T. acutum* form a series connecting the generalized and not strictly existent *T. pyxidiferum* of the Orient with the highly specialized *T. pallidum,* and may reasonably be regarded as representing steps in the evolution of the last species, whatever the exact ancestor of the series as a whole.

10. TRICHOMANES ACUTUM Presl.

T. acutum PRESL, Hymenophyllaceae (1843) 134.

Pleuromanes acutum PRESL, Epimeliae (1849) 258.

T. fuscoglaucescens HOOKER, ex J. Smith, Journ. Bot. 3 (1841) 417, nomen, meant to be *T. glaucofuscum.*

T. glaucofuscum HOOKER, Sp. Fil. 1 : 128, as to the Luzon plant, pl. 40 A.

T. fronde oblongo-lanceolata obtusa glaberrima profundissime bipinnatifida basi pinnata, laciniis primariis pinnisque oblongo-lanceolatis acuminatis, secundariis oblongis, bi-trilobis, lobis linearibus acutis mucronulatis integerrimis, soris exsertis, indusii limbo patente integro, receptaculo recto. *Cuming pl. exs. philip. n. 219.*

Habitat in insulis philippinis, praesertim in insula Luzon, ubi legit clar. Cuming.—Presl, Hymen. 134.

The frond is usually lanceolate rather than oblong-lanceolate, acute rather than obtuse, glabrescent instead of very glabrous; the rachis is narrowly winged to the base; the segments are usually but not always acute; the base of the involucre is usually distinctly immersed; and the receptacle is curved if full-grown and intact, which is a rare condition in herbarium specimens.

The fronds are large and long, 20 to 30 cm in length; the axial pad is contracted to a thick-walled cortex such as occurs generally in the genus; it is therefore naked as compared with *T. pallidum,* but young fronds bear a few long hairs like those of that species; the involucre is 2 to 2.5 mm long, with a flaring mouth 1.5 mm wide. Otherwise it is like the plants of Polynesia and Ceylon, with which Hooker, at that time not knowing *T. pallidum,* confused it as *T. glaucofuscum.*

Known only from the mountains of northern Luzon, *Cuming 219* (type), in Gray Herbarium (two sheets), United States Na-

tional Herbarium, and Bureau of Science herbarium; *Bur. Sci. 19619, 19679, 37518, 37732, 37761, 40409; Merrill 7813; Topping 200.*

11. TRICHOMANES PALLIDUM Blume.

T. pallidum BLUME, Enumeratio (1828) 225.
Pleuromanes pallidum PRESL, Epim. 258.
Craspedoneuron pallidum VAN DEN BOSCH, Hymen. Javan. 14, pl. 8.
T. album BLUME, Enum. 226.
Leucomanes album PRESL, Epim. 258.
Craspedoneuron album VAN DEN BOSCH, Hymen. Javan. 12, pl. 7.
T. glaucofuscum HOOKER, in Nightingale's Sketches 131; Sp. Fil. 1: 128, except as to the Luzon plant.
Craspedoneuron Braunii VAN DEN BOSCH, Hymen. Javan. 15, pl. 9.
T. savaiense LAUTERBACH, Engler's Jahrb. 41 (1908) 218.

T. fronde bipinnatifida oblonga sparsim setosa glaucescente (plant. jun. pinnatifido-digitata), pinnis subalternis cuneato-oblongis pinnatifidis, laciniis cuneiformibus subbifidis, lacinulis linearibus obtusis emarginatis, rachi alata, stipite tereti glabro.

Obs. Maxime affine *Tr. lucenti,* Sw.

Crescit ad truncos arborum in Javae sylvis primaevis.

Var. B. *Glaucum,* pinnis suboppositis approximatis pinnatifidis, laciniis linearibus obtusis emarginatis.

Crescit in arboribus Provinciae javanicae Bantam.—Blume, loc. cit.

Trichomanes album Blume, Enum. (1828) 226:

T. fronde bipinnatifida ovato-oblonga strigosa albida, pinnis oppositis alternisve cuneato-lanceolatis pinnatifidis, laciniis cuneiformibus incisis, lacinulis linearibus subbifidis, rachi marginata, stipite tereti glabro.

Crescit in Javae montibus excelsis.

This is one of the most distinct species in the genus—after the removal of *Cardiomanes,* and dealing only with the Old World. The margin, responsible for van den Bosch's generic name, *Craspedoneuron,* is peculiar, and apparently far from uniform—compare the figures of van den Bosch, Hymen. Javanicae, pl. 10, and of Mettenius. A marginal row of small, more or less elongate cells, apparently thin-walled, is sometimes evident. The next row inward has thick, dark walls, and may be two cells in depth.

The veins are immersed in a broadly flattened strand or pad of thick-walled cells, which, misinterpreted, was responsible for Presl's first generic name, *Pleuromanes.* This pad is several cells thick in the middle, and thins to two toward the margin. Van den Bosch, giving more accurate definition to Blume's two species, *T. pallidum* and *T. album,* assigned to the latter the specimens with a one-cell-thick wing a couple of cells wide,

between the pad and the specialized margin; to the former, the specimens with the wing half a dozen cells wide; specimens with a still wider wing, and correspondingly narrow pad, constituted his third species, *T.* or *C. Braunii.* Confining attention to Javan specimens, with which alone he dealt, I cannot see that they fall into distinct groups. Rarely, the wing is obsolete, the pad extending to the submarginal strand; elsewhere on the same fronds the wing is one, two, or three cells wide. On other fronds, it varies from 2 to 4 or 5 cells, or from 3 to 6, 5 to 9, etc. I find no correlation between the width of the pad and any other character except the pubescence. Accordingly, I regard the three Javan "species" as one. Beyond Java, the commonest form is the typical *T. pallidum* in Sumatra, Borneo, the southern Philippines, and Papua. Farther north and east, in Ceylon, the Peninsula, the central Philippines and Luzon, and from New Caledonia to the Marquesas, it is *T. Braunii,* with narrow axial pad and correspondingly naked fronds, whether or not strongly glaucous.

Presl's second generic name, *Leucomanes,* published without a diagnosis, may refer to either or both of the remaining striking characteristics of the species. The fronds are glaucous, the glaucousness varying from almost obsolete to a dense white or bluish granular coating; and they are hairly, with hairs consisting of one cell above the base, usually 0.2 to 0.5 mm long, but sometimes reaching 1 mm. When short, the hairs are rigid; long ones may be weak. They are restricted to the pad and margin, wherefore *T. Braunii* represents the most-naked form, and *T. album* the most hairy; but, even when the pad is widest, the hairiness is very variable in density and in persistence.

Rhizome wide-creeping or intricate, on mossy trunks, 0.2 to 0.3 mm in diameter, hairy or glabrescent; stipes wiry, terete, dark, glabrescent, commonly 5 cm long; fronds pendent, flaccid, ovate if small, lanceolate if large, commonly 5 to 20 cm long, bipinnatifid with simple or forked segments, the rachis winged by decurrent pinnæ, narrowly toward the base of slender fronds; sori on shortened basal acroscopic segments, with tubular involucre 1 to 1.5 mm long, truncate or slightly dilated and undulate, the base more or less immersed, the wing often obsolete toward the mouth. Polynesian specimens average larger than Malayan, beside being relatively thin and naked; they are *T. glaucofuscum* Hooker, based probably on a Huahine collection. I have not seen authentic *T. savaiense,* nor any frond as much as

40 cm long; but specimens collected in Samoa by Whitmee, Reinecke, Powell, and Betche, reaching a length of 25 cm, are *T. pallidum*, or *T. glaucofuscum* if one will, and indistinguishable from those of Tahiti and Ceylon, or exceptionally large ones from any part of the range of the species.

Common in the mossy forest, throughout the Malay region and to central Luzon (rare in northern Luzon); Ceylon; Amboina; Papua; New Caledonia; Samoa; Society Islands; Marquesas (*Bertero*).

4. GONOCORMUS; THE GROUP OF TRICHOMANES PROLIFERUM

Rhizome and stipe dark, wiry; fronds minute, flabellate in plan and venation, simple but incised between the veins, sometimes nearly to the base, with short, narrow, firm, dark green segments, usually emarginate, without false veins, specialized margin, or hairs; sori immersed in the apices of the segments, with elongate, sometimes ventricose tube and flaring mouth. The most striking peculiarity of the group is the lack of differentiation of rhizome and stipe shown by the presence, at least on strong fronds, of a bud at the top of the stipe—respectively, the base of the frond—which can produce a stipe bearing another frond, or even, rarely, produce a rhizome. As this process may be repeated several times, the definition of the frond becomes an arbitrary matter; except in the exceptional case in which the bud produces a rhizome, of unlimited growth, I find it convenient to treat the original frond and its derivatives, of limited number, as one frond, and to designate the several laminæ as "part-fronds." Only the upper members of such a series are usually soriferous. Mettenius, Über die Hymen. 406, seemed to believe the adventive bud a constant character of the group, by which a *Gonocormus* could be recognized even in the absence of actual proliferation. I have been able to detect it on some, but not on most, simple fronds. That emphasis belongs on the lack of differentiation of rhizome and stipe, rather than on the buds, which illustrate this lack, is shown by the occasional formation of terminal fronds on rhizomes typical up to that point. The distal part of a compound frond may be pinnate, instead of dichotomous, in plan; and so, less conspicuously, may be a simple frond. This occasional pinnate branching, and the form of the involucre, indicate affinity to the group of *T. pyxidiferum*. Although *Gonocormus* is a tenable genus, if one will, its affinity to the body of *Trichomanes*

is clear, but there is no near affinity to *Microtrichomanes*. The range is from Fernando Po, west of Africa, to Hawaii, north to Japan, and south to Australia.

Within the group, the species are very ill-differentiated. The range in size and in form, depending chiefly upon the degree of proliferation, is so great that if attention be directed to the differences, as naturally happens when but few specimens are known, there seem to be a number of easily distinguishable species. With the accumulation of material, these blend, until I doubt there being a species in the group which does not intergrade with the others. In fact, I believe that specimens typical of every described species are found on the very limited area at the summit of Mount Maquiling, in central Luzon, but feel sure that all of these specimens represent a single species. As a matter of botanical philosophy, I believe that two (or more) species which are reasonably uniform and distinct in Java are good species in Java, and that the propriety of so recognizing them is not seriously impaired by their blending in Luzon. Chiefly on this ground, and in minor part in deference to established usage, I present the Javan species recognized as such by van den Bosch in his Hymenophyllaceae Javanicae, with a key based on the conventional distinctions.

Besides the species I have recognized or reduced, there are two described from New Guinea, *T. novo-guineense* Brause, Bot. Jahrb. 49 (1912) 7, and *T. subtilissimum* Brause, Bot. Jahrb. 56 (1920) 33, known to me by description only; because of the instability and polymorphism of all *Gonocormus* species, I mistrust them, but they may easily be as distinct and stable as those I recognize.

There is also in Samoa a *Gonocormus*, represented in the Gray Herbarium by *Powell 102*, collected in 1863, far more sharply distinct from the local form of *T. parvulum* than is any Javan "species" from any other. In Java or Sumatra, it might be construed as *T. Teysmannii*. In Samoa, it is a distinct species. So far as *T. Teysmannii* is concerned, I would describe and name it, in spite of my hesitancy to regard any *Gonocormus* as distinct, but abstain because of the possibility that it is a large *T. novo-guineense*. The fronds are mostly about 6 cm long and 2.5 cm broad, but variable in the manner of the group. Few of those seen are proliferous. The architecture is pinnate throughout, except as disturbed by the proliferation.

Key to the species.

Sori on ordinary fronds or part-fronds.
  Axes not proliferous .... 12. *T. parvulum.*
  Axes proliferous.
    Proliferations scanty.
      Segments plane .... 13. *T. minutum.*
      Segments somewhat folded .... 14. *T. diffusum.*
    More conspicuously ramose.
      Lateral walls uniform .... 16. *T. Teysmannii.*
      Walls irregularly thickened .... 15. *T. proliferum.*
Sori in a long apical "raceme".. 17. *T. alagense.*

12. TRICHOMANES PARVULUM Poiret. Plate 5.

T. parvulum POIRET in Lam. Enc. 8 (1808) 64; HOOKER, Sp. Fil. 1: 118, pl. 39A; OGATA, Ic. Fil. Japon. pl. 199.
T. saxifragoides PRESL, Hymen. 131.
T. thouarsianum PRESL, Hymen. 132.
T. subpinnatifidum VAN DEN BOSCH, Ned. Kr. Arch. 5 (1861) 141; Journ. Bot. Néerl. 1 (1861) 345; Meded. Rijks Herb. 17 (1913) 25, fig. 14 (based on a Ceylon specimen collected by Gardner).
T. Mannii HOOKER, Synopsis Fil. (1867) 75.
T. musolense BRAUSE, Bot. Jahrb. 53 (1915) 377.

Trichomanes pusillum, frondibus minimis, variè dissectis, patentibus, glaberrimis; laciniis apice subdichotomis, obtusis; fructificatione compressâ, terminali, urceolatâ. (N).

Cette espèce . . . n'a guère que trois à quatre lignes au plus de haut; . . . ses pétioles . . . supportent une petite feuille simple, membraneuse, verdâtre, très-glabre, transparente . . . divisée presque jusqu'à sa base en découpures très-inégales, courtes, presque linéaires, entières ou bifurquées . . .

. . . recouillie par M. du Petit-Thouars à l'île de Madagascar.—Poiret, loc. cit.

I have seen no Madagascar specimen referable to this species, but have specimens of other origin from the Paris Museum and from Prince Bonaparte, which ought to be authentic. What I construe as the typical form has fronds about 1 cm in diameter, reniform or circular when sufficiently branched to produce this form, or fan-shaped if more simple, the margin shallowly incised between the ultimate veinlets, and more deeply between the groups of veins, with a more or less marked tendency of the medial segments to exceed the lateral ones and thus produce ovate or moderately elongate fronds; stipe more or less as long as the frond; sorus immersed in the tips of segments, the involucre narrowly campanulate or longer and moderately ventricose, the mouth dilated or flaring but not bilabiate.

Very variable in size and shape. *Trichomanes saxifragoides* was founded on *Cuming 256,* from Luzon, of which cotypes are in the Gray Herbarium, United States National Herbarium, Bureau of Science, and my own herbarium. It is a minute form, the largest fronds sometimes not over 5 mm in diameter, usually flabelliform or less than semicircular, with few segments. It is not rare in the Philippines, and varies greatly in the depth of the incisions. The sori may be on short segments, as stated by van den Bosch, Hymen. Javan. 9, and thus fall short of the general contour of the frond, or they may be on the longest segments, as stated by Presl. The sori are small, proportionate to the fronds. On these minute fronds, the tendency is for the segments to approximate equality; still, as Presl recognized, the central segments may be preferred. I have tried to find a line between these minute forms and typical *T. parvulum,* tentatively using 8 mm as a boundary, but have come to the conclusion, with the accumulation of Philippine material, that any line is arbitrary. There are no distinctions except in size or in correlation with size, and in size it blends in the Philippines with the forms which have been recognized as *T. parvulum* or called *T. minutum.* As the type is Philippine, the species falls when found inconstant there. Similar minute plants have been given this name in Indo-China, Borneo, Rawak, New Caledonia, Fiji, and Hawaii, and can probably be found whenever *T. parvulum* occurs.

The larger forms of *T. parvulum* vary more widely, in form as well as in size. Some collections are composed of almost uniform, beautifully round fronds: *Bur. Sci. 17654 Ramos,* from Samar, with many reniform to circular, flat fronds 12 mm in diameter overlying an older crop with folded segments which, by themselves, could be *T. saxifragoides.* Japanese collections are likely to be fairly uniform, but semicircular rather than more fully rounded out. In most lands, the segments tend to be more unequal, and ovate or elongate fronds predominate, however broad the base may be. A width of more than 12 mm and a length of 2 cm are unusual, but abnormal fronds may double these dimensions; and with exceptional inequality in the development of the axes of growth, there is hardly a limit to the forms the fronds assume.

Typically and usually, *T. parvulum* is not proliferous. However, I have been able to detect some proliferation in specimens from every land whence I have seen the plant. It is commoner on the larger and less symmetrical forms; but even in the type

collection of *T. saxifragoides* I have found fronds with only half a dozen segments with a narrowly cuneiform bifid appendage on the "stipe."

Trichomanes subpinnatifidum and the *Hymenophyllum Gardneri* with which it was found mixed are overlooked or ignored by Hooker and Baker, Thwaites, Beddome, and Wall. Specimens collected in Ceylon by Ferguson, by Naylor Beckett, and by Thwaites conform reasonably to van den Bosch's description; they are distributed, correctly, as *T. parvulum*. Also, van den Bosch's figure, Meded. Rijks Herb. fig. 14, represents *T. parvulum* as far as it goes; in particular, the very thin outer wall of the marginal cells is more correctly drawn than in any of his figures in Hymenophyllaceae Javanicae.

I do not know whether or not *T. parvulum* and *T. thouarsianum*, based on a Thouars collection ascribed to Bourbon, were described from the same collection; at any rate it occurs in Madagascar (Bonaparte, Notes Pterid., Fasc. 16: 14, 158) and the other East African islands; Africa: *Dümmer 1221* in the United States National Herbarium, from Uganda; and thence practically everywhere to Korea and Japan, the Malay region, Papua, New Caledonia, Australia, Fiji, Samoa, Tahiti, the Marquesas, and Hawaii.

The Marquesas plant, *Mumford and Adamson 361*, is small but notably proliferous. I do not consider it possible to regard it as *T. proliferum*, as a proper species distinct from *T. parvulum*; if distinguished at all from the latter, it must be as a species of evolution parallel to that of *T. proliferum*, and it may be characterized further by having a notably wide, flat mouth of the involucre.

In the posthumous publication of the notes left by van den Bosch, Meded. v.'s Rijks Herbarium, No. 17 (1913), *T. thouarsianum* appears on page 19 as a synonym of *T. parvulum* and on page 22 as an independent species. The figure 9, page 19, is quite certainly not this species, but *T. sibthorpioides*, cited by van den Bosch as a synonym. With only a sterile specimen, the confusion was easy.

Trichomanes Mannii [= *T. mannianum* Mett. in Kuhn, Fil. Afric. (1868) 34], represented by a cotype in the Gray Herbarium, is distinct from *T. parvulum* in no respect unless it be in size, reaching a width, on the sheet seen, of 2 cm and a length of 3 cm. Among the species of the Malay region, it is most exactly duplicated by *T. diffusum*, but it seems more reasonable to reduce it to *T. parvulum* than to postulate a remarkably

discontinuous distribution for *T. diffusum,* while I regard the distinctness of that species in any place as questionable. Exceptional specimens of *T. parvulum* from other places are as large as are the Fernando Po specimens. The "broad plaited wing all round the mouth of the involucre" (Syn. Fil. 76) is merely the moderately overfull dilated mouth of the involucre common in the group, well shown by van den Bosch's figure of *T. diffusum,* Hymen. Javan., pl. 4. *Trichomanes musolense* was also described from Fernando Po, recognized as a relative of *T. proliferum,* and provided with a description which does not differ essentially from that of *T. Mannii,* except in length.

Finally, every detail in the description of *T. gracile,* known to me, as to van Alderwerelt, by description only, marks it as a *Gonocormus,* indistinguishable from a nonproliferous *T. Teysmannii.* It may be reduced to the latter, or to *T. parvulum;* and I suppose that *T. melanotrichum* Schlecht. may suffer the same fate.

13. TRICHOMANES MINUTUM Blume.

Trichomanes minutum BLUME, Enum. (1828) 223.
Gonocormus minutus VAN DEN BOSCH, Hymen. Javan. 7, pl. 3.

T. fronde (subbinata aut ternata) longe stipitata, foliis petiolatis subrotundis basi cuneatis palmato-incisis glabris, laciniis linearibus obtusis bifidis.

Obs. A priori [T. parvulum Poir.] differt fronde longe stipitata basi cuneata et laciniis plerumque bifidis aut bipartitis.

Crescit in Javae montibus ad arborum truncos muscosos.—Blume, loc. cit.

In this species, van den Bosch included Blume's *T. parvulum* and *T. bifolium,* but modified the description to make it include moderately proliferous plants with plane segments. As Blume construed as fronds what I call "part-fronds," this modification was only apparent, and entirely reasonable. From the considerable number of collections in hand, and having myself undertaken to identify and distinguish Blume's species on Mount Gedeh, I agree with van den Bosch that the three Blumean species blend and are one. It is also my observation that proliferation is commoner here than in lands where *T. parvulum* is more typical in its character. This is the whole of the difference; *T. minutum* is prone to moderate proliferation, which is rare in *T. parvulum.*

Distinguishing them in this manner, *T. minutum* is common in Java and the Peninsula, and probably throughout the Malay region, and not rare in the Philippines.

14. TRICHOMANES DIFFUSUM Blume.

Trichomanes diffusum BLUME, Enum. (1828) 225.
Gonocormus diffusus VAN DEN BOSCH, Hymen. Javan. 9, pl. 4.

T. fronde bipinnatifida diaphana glabra, pinnis alternis vel oppositis remotis lanceolatis, infimis stipitatis, superioribus confluentibus, lobato-pinnatifidis, laciniis linearibus obtuse dentatis, receptaculis solitariis geminisve, rachi superne marginata, stipite tereti glabro.

Crescit in montanis Javae locis muscosis.

Var. B. pinnis omnibus sessilibus, laciniis subintegerrimis, rachi tota marginata.

Crescit in monte Tidore insulae.—Blume, loc. cit.

Trichomanes diffusum Bl. (excl. var. B) diff. a T. minuto: frondiculis e basi cuneata obovatis oblongisve complicatis, lacinulis semper pinnatifidis, sororum forma et magnitudine fere duplo, cellulis multo majoribus caet., a *T. prolifero* statura minore, rhachi alata, indusio ventricoso, cellulis tenerioribus majoribus fuscis caet.—Java, in m. Gedé Bl., Insula Marchesas: Lepine.—Van den Bosch, Journ. Bot. Néerl. 1 (1861) 345.

Blume distinguished this from *T. minutum* by its being pinnate rather than flabellate in plan; but this distinction is at best one of degree, neither "species" being fixed in the character ascribed to it. I have keyed them apart by one of van den Bosch's distinctions; namely, that the segments of *T. minutum* are plane, while those of *T. diffusum* are prone to fold upward, on the costa as an axis, or to become variously contorted. This is correlated with a microscopic difference in structure, the cell walls of his *T. minutum* being broadly pitted, the narrow divisions between the pits looking like teeth. I am not yet sure on this point, but it is my impression that the partial thickening of the walls is under the direct influence of the environment, so that the fronds of a single plant may show it in one season and not in another. The ability to react in this way seems to me to be a characteristic of *Gonocormus*, and not to distinguish any of its supposed species.

I do not believe that even convenience is served by maintaining *T. diffusum* as a species distinct from *T. minutum*.

Trichomanes subtrifidum Matthew and Christ, Journ. Linn. Soc. Bot. 39 (1909) 214, described as a dwarf relative of *T. pyxidiferum*, was found on Mount Maquiling, altitude 3,000 feet, where *Gonocormus* is a riot of forms, common and bizarre. Without seeing the type collection, I feel sure that it is one of these, and that none of them, however distinct in individual aspect, is a good species. By description, it would reduce best to *T. diffusum;* but I prefer to be more thorough, and regard it as a peculiar form of *T. parvulum*. Plate 5, figs. 4 and 5, shows two fronds on the same rhizome, from a Yunnan specimen,

Hancock 136, U. S. Nat. Herb. 1277595. The larger of these fronds suggests the description of *T. subtrifidum.* I illustrate this, rather than a Maquiling specimen, to show that such behavior is not a local phenomenon.

15. TRICHOMANES PROLIFERUM Blume.

T. proliferum BLUME, Enum. (1828) 224; HOOKER, Sp. Fil. 1: 118, pl. 39B.
Gonocormus prolifer PRANTL, Hymen. 51.
T. palmatum PRESL, Hymen. 131.
Gonocormus palmatus VAN DEN BOSCH, Hymen. Javan. 11, pl. 6.

T. fronde (subbinata aut ternata) longe stipitata subrotunda basi cuneata palmato-incisa glabra, laciniis pinnatifidis.

Obs. A praecedentibus [T. parvulum and T. minutum] differt laciniis pinnatifidis.

Crescit in truncis arborum Javae.—Blume, loc. cit.

The sole distinctive feature of this species is its comparatively free proliferation, the series of successive part-fronds running commonly to about four; and it is not rare for two (or even three) secondary stipes to spring from the base of one part-frond. The luxuriance of these plants finds another expression in a marked tendency to pinnate development of the part-fronds. With the understanding that it intergrades with *T. minutum,* it remains convenient to give specific status to this luxuriant form. It is probably common throughout the Malay region.

Philippine specimens may be exactly like Javan, but have a clearly marked tendency toward restriction of the sori toward the apex of the frond, and the reduction of the lamina there. This tendency is independent of the proliferation, appearing either on the upper part-fronds or on nonproliferous fronds of the same cultures. Where it occurs, the local frond plan is pinnate. To the extent that this distinction between the races in Java and Sumatra, and in the Philippines is a fixed one, *T. proliferum* and *T. palmatum* are distinct species. If either were clearly, instead of vaguely, distinct from *T. parvulum,* I would treat them as distinct from one another.

The common Peninsular form has also its own varietal character, both the fronds as a whole and the part-fronds averaging distinctly smaller than in Java and Sumatra.

16. TRICHOMANES TEYSMANNI van den Bosch. Plate 6, figs. 1 to 3.

Trichomanes Teysmanni VAN DEN BOSCH, Ned. Kruid. Arch. 5[2] (1861) 142.
Gonocormus Teysmanni VAN DEN BOSCH, Hymen. Javan. (1861) 10, pl. 5.

Frondiculis e flavo virescentibus diaphanis lanceolatis vel lineari-lanceolatis bipinnatifidis, laciniis primariis subpatulis remotiusculis subrhombeis saepe elongatis, secundariis erectis contiguis furcato-flabellatis, lacinulis fastigiatis e cellulis magnis hyalinis elongato-hexaëdris viridiglobulosis contextis, rhachi anguste alata, soris latiuscule marginatis, indusio cylindrico-ventricoso, limbo amplo patente subundulato, stipite fronde subtriplo breviore apice anguste alato.

Hab. ad arborum truncos muscosos in littore occidentali Sumatrae, *Teysmann*.

. . . Stipes apice anguste alatus, caeterum filiformis teres glaber 5–15 millim. longus; frondes secundariae s. ex stipite s. ex rhachi angulo plerumque obtuso vel recto exeuntes 2–5 centim. longae, 5–8 millim. latae frondi primariae, usque 5 centim. longae et 12–15 millim. latae, excepta magnitudine, universe conformes . . .

Species formae gracilitate et contextu tenero insignis, ab antecedentibus [G. minuto et G. diffuso] longe recedens, sequenti [G. palmato] proxima, a qua vero facile distinguitur: habitu, divisione frondis, rhachi stipiteque apice alatis, cellulis minoribus teneris globulosis, indusio breviore magis ventricoso, etc. . . .—Van den Bosch, Hymen. Javan., loc. cit.

Such distinctions as van den Bosch thought to exist are presented in the foregoing quotation. They do not appeal to me as very real. Aside from the dubious gross distinctions, *T. Teysmannii* should have plane and smooth laminar cell walls, while *T. proliferum* should have them irregular and pitted or toothed; my view of this feature is stated in the discussion of *T. diffusum*.

Specimens conforming to the description of *T. Teysmannii* occur in Java, Sumatra, and the Peninsula.

Recognizing plural species of *Gonocormus*, *T. Teysmannii* is the best one to which to assign some anomalous Javan specimens which, by the terms of the usual gross diagnosis, would seem to be *T. pyxidiferum*, but which a more understanding inspection shows to be *Gonocormus*. Such are a collection by Hallier from Tjipinas, *Raciborski 62b* from Tjiapoes (both received in Manila from Buitenzorg as "nov. sp."), and *Palmer and Bryant 596* and *677*, in the United States National Herbarium with my own determination as *T. pyxidiferum*; also *Mousset 5*, distributed with the same name, and *Yates 670*, distributed as *T. bipunctatum*. All are large for the group, lanceolate in major part, and with only a trace of proliferation. Fronds of the Palmer and Bryant specimens reach a maximum length of 13 cm, and fertile ones vary in shape from 60 by 9 mm to 33 by 22 mm. Some fronds on all specimens exactly match some of those figured by van den Bosch for *T. Teysmannii*. To one disposed to recognize many species of *Gonocormus*, these might well represent still another.

17. TRICHOMANES (GONOCORMUS) ALAGENSE Christ. Plate 6, figs. 4 to 7.

Trichomanes (*Gonocormus*) *alagense* CHRIST, Philip. Journ. Sci. 3 (1908) Bot. 270.

In genere egregium fronde fere lineari, ad basin solummodo pinnatifida, sed versus apicem in spicam elongatam urceolarum pedunculatarum elegantissime producta. Species minuta caespitosa.

Rhizomate intertexto-filiformi setuloso nigro, foliis approximatis, caespitosis, stipite capillaceo nigro 2 cm longo debili, fronde e basi latiori lineari-lanceolata 3 ad 4 cm longa, basi pinnis 4 aut 5 utrinque confertis cuneato-flabellatis 0.5 cm longis et latis, profunde bipinnatisectis munita, lobis ultimis vix 1 mm latis, ca. 7, obtusis, nervis flabellatim furcatis, in lobis singulis, nigris; fronde versus medium in spicam linearem contracta, rhachi filiformi sed tenuissime alata, urceolis 10 ad 12 pedunculatis alternis campanulatis, pedunculis 2.5 mm longis, inferioribus furcatis, urceolis 1.5 mm longis eleganter campanulatis, margine tenuissimo cinctis, ore dilatato, receptaculo exserto.

MINDORO, Alag River. *Merrill 6062*, November, 1906.

Ab omnibus *Goniocormis* ab Van den Bosch pictis spica terminali discrepans, potius *G. Teysmanni* V. d. Bosch Hym. Jav. *t. 5* comparanda.—Christ, loc. cit.

This should be compared with *T. palmatum* Presl, not with *T. Teysmannii.* The tendency of the sori to crowd to the distal end of the frond, where the lamina is reduced, is carried farther, making *T. alagense* the end of this evolutionary line. This species is more distinct than are any of those immediately preceding, but even in this case I have collections from Mount Maquiling and from Rizal which may with about equal propriety be called *T. parvulum, T. proliferum,* or *T. alagense.*

DOUBTFUL SPECIES OF GONOCORMUS

TRICHOMANES NOVO-GUINEENSE Brause, Bot. Jahrb. 49 (1912) 7.

Eutrichomanes. Rhizoma repens, filiforme, pilosum, folia densa petiolata interdum prolifera emittens. Petioli tenuissimi, angustissime alati, usque ad 3,5 cm longi, glabri. Laminae membranaceae, pellucidae, glabrae, cr. 3,2 cm longae, 1,8 cm latae, ambitu sublanceolatae, in apicem brevem furcatum desinentes, basi vix angustatae, bipinnato-pinnatifidae; pinnis primariis petiolatis, pinnato-pinnatifidis, patentibus, cr. 6-jugis, alternis, cr. 4 mm distantibus, medianis maximis 1,2 cm longis; pinnis secundariis basalibus supra inferiorum pinnarum primariarum costam petiolatis, profunde unijuge pinnatifidis, cr. 0,7 cm longis, 0,9 cm latis; segmentis cuneatis, incisis, apice obtusiusculo crenulatis; rachibus petiolis similibus angustissime alatis, glabris; costis nervisque validis; nervis simplicibus vel furcatis. Sori superiorem laminae partem occupantes, pauci, plerumque 2-jugi, bini in utroque rachis latere, petiolati (petiolis cr. 2 mm longis), marginati; indusiis 1,5–2 mm longis, orificio dilatato cupuliformibus, ramis nervi furcati inclusis; receptaculo brevi, tenui.

*   *   *   *   *   *   *

Nordöstl. Neu-Guinea: Kaiser-Wilhelmsland, Lager Hochmoos, 65 km südwärts der Tami-Mündung, 1600 m ü. M. (L. Schultze n. (33) 35.— Juli 1910).

Steht dem Habitus nach *T. Colensoi* HOOK. nahe, die Form der Sori ist sehr ähnlich, aber bei letzterem sind die Fiederabschnitte weniger zerteilt. Sehr auffallend bei der neuen Art ist, dass sie ähnlich wie *T. proliferum* Bl. proliferiert . . .

TRICHOMANES SUBTILISSIMUM Brause, Bot. Jahrb. 56 (1920) 33.

Eutrichomanes proliferum. Rhizoma repens, tenuissimum, nigrum, pilis brevibus articulatis brunneis instructum, folia petiolata interstitiis 1–4 mm longis emittens. Petioli tenuissimi, 2–6 mm longi, saepe flexuosi, virides, ad basin versus brunnescentes, juventute basi pilis iis rhizomatis aequalibus, sparsis praediti, frequenter proliferi. Lamina ambitu lineari-lanceolata, basi vix angustata, in apicem obtusiusculum soriferum desinens, 0,6–2,4 cm longa, 0,5–0,7 cm lata, pinnato-pinnatifida; pinnis 8–11-jugis, petiolulatis, interstitiis 2–2,5 mm longis remotis, patentibus, alternis, dimidiatis, maximis 0,4 cm longis, 0,3 cm latis, ambitu flabelliformibus, usque ad costam pinnatifidis; segmentis 2–3, dichotomis vel furcatis; laciniis linearibus, angustissimis, margine subintegris, raro minute denticulatis; rachibus filiformibus, glabris, interdum proliferis. Sori in specimine singuli in utroque rachis apicis latere, indusio cylindrico, 1,2 mm longo, 0,5 mm lato, ore paulo dilatato, receptaculo tenuissimo paululo exserto.

* * * * * * *

Nordöstl. Neu-Guinea: Kaiserin-Augusta-Fluss-(Sepik-) Gebiet: Hunsteinspitze, lichter Gebirgswald; dunkelgrüner Farn, einzeln im Moospolster. 1350 m ü M. (Ledermann n. 8493—22. Aug. 1912).

Zarteste kleine Art, kaum einer der bekannten Arten ähnelnd. Sie fällt auch durch ihr häufiges und unregelmässiges Proliferieren an den verschiedensten Stellen der Rachis und des Blattstieles auf.

5. MICROTRICHOMANES; THE GROUP OF TRICHOMANES DIGITATUM

Epiphytes, with finely filiform rhizomes and remote stipes; fronds dichotomous, rarely somewhat monopodial, the axes winged throughout, but the stipes not so, without false veinlets, or veins except the costæ of the segments, and without specialized margin, but often ciliate or setiferous; lamina dark in most species, commonly brownish, walls thin but likely to appear thick because seen with the contents of the cells closely applied to them; sori terminal on the longer segments, with usually obconic involucres, winged to the top; receptacle exserted but short.

A group of small and delicate epiphytes, ranging from the East African islands across Polynesia. The brownish color, the hairs of some species and the teeth of others, and the shape of the involucre (lips excluded), all suggest *Leptocionium* so strongly as to force a suspicion of affinity. Within *Trichomanes*,

certain species of *Hemiphlebium,* as *T. vitiense,* are quite surely reduced derivatives of *Microtrichomanes.* In the other direction, I am in doubt as to the affinity of this group and that of *T. pyxidiferum.* Any affinity to *Gonocormus* is still more doubtful. The chief desideratum, before any classification of the species here assembled can be accepted with confidence, is a knowledge of the stages in the development of young sporophytes. The group name, proposed by Mettenius, Über die Hymen. (1865), was used by Prantl, Hymen. (1875) 51, for a section of his genus *Gonocormus.*

Trichomanes digitatum and *T. nitidulum* are wide-spread species, the others comparatively local.

Key to the species.

Margin entire, without hairs or bristles.
  Lip entire.
    Segments borne at an acute angle .... 20. *T. nitidulum.*
    Segments widely divergent, short .... 21. *T. Francii.*
  Lip toothed .... 18. *T. sibthorpioides.*
Margin bearing dark setæ, lip entire.
  Fronds irregularly monopodial, up to 10 cm long .... 25. *T. dichotomum.*
  Segments more uniform and fronds shorter.
    Segments few, commonly 2 to 6 .... 23. *T. digitatum.*
    Segments many, commonly 10 to 30 .... 26. *T. taeniatum.*
Margin and veins hairy, hairs simple, lip entire.
  Fronds as broad as long .... 27. *T. palmatifidum.*
  Fronds elongate, segments few .... 28. *T. Ridleyi.*
Margin and lip toothed, ciliate with branched hairs .... 29. *T. Lyallii.*

18. **TRICHOMANES SIBTHORPIOIDES** Bory. Plate 8.

Trichomanes sibthorpioides BORY, in Willd., Spec. Plantarum 5 (1808) 498.

Hymenophyllum sibthorpioides METTENIUS, in Kuhn, Fil. Afric. 41.

T. frondibus reniformibus stipitatis palmato-incisis, laciniis linearibus obtusis emarginatis. W.

T. frondibus subpeltatis reniformibus crenatis pedatis dichotomis. *Bory in litt.*

Sibthorpienartiger Becherfarrn. W.

Habitat in nemoribus insulae Borboniae. ♃ (*v. s.*)

Caudex *filiformis crassitie setae equinae repens glaber.* Stipes *trilinearis filiformis glaber.* Frons *trilinearis reniformis, ultra medium palmato-incisa, tenuissime membranacea.* Laciniae *lineares integerrimae obtusae, majores emarginatae.* Sori *sub apice laciniarum.* W.—Bory and Willdenow, loc. cit.

This has been confused in synonymy with *T. parvulum,* and with what I suppose to be *T. digitatum.* I know it from a single specimen, *Hillebrand 3779,* received from Berlin as *H. sibthor-*

pioides Mett., which I feel justified in regarding as perfectly authentic. Sharing the characters of the two species just referred to, it is distinct from both. It has the texture and tendency to curl of *Gonocormus,* justifying the reference to *T. parvulum* as long as sterile fronds alone are known. The sori are rather those of *Microtrichomanes,* more particularly like those of *T. Lyallii* in shape and margin; but my specimen shows no trace of hairs, nor are there the dark cells which are at the bases of the hairs of *T. Lyallii* and *T. palmatifidum,* wherefore I believe the hairs really to be absent. Nevertheless, I believe that the nearest affinity is to this group.

Reports elsewhere than Madagascar are to be doubted.

19. TRICHOMANES BARKLIANUM Baker.

T. Barklianum BAKER, Journ. Linn. Soc. Bot. **9** (1867) 338, pl. 8, fig. F.

Frondibus stipitatis lineari-oblongis indivisis, venis pinnatim dispositis, venulis spuriis nullis, involucro solitario terminali, ore integro late alato.

Rhizome slender, creeping, copiously branched, matted with brown tomentum. Stipes one to two lines long, tomentose. Frond membranaceous in texture, not more than two or three lines long by one broad, in shape irregularly linear-oblong, the edge a distinct undulated line, more or less clearly ciliated, the blade furnished with a distinct midrib, from which proceed, at an angle of about 45°, to the margin, at nearly regular intervals, six to eight erecto-patent lateral veins on each side; intervenary spaces not reticulated; sori solitary, placed at the apex of the terminal vein, into which the base is narrowed gradually; the mouth broadly winged, but not two-lipped; the apex of the frond continuous with the wing on one side; the receptacle equal to the involucre or exserted. Discovered by Sir Henry Barkly, the Governor of Mauritius, and Lady Barkly, at the Tamari cascade in that island. This species and Hymenophyllum parvifolium, described below, are probably the most diminutive of known ferns, as it would take upwards of fifty fronds of average size to cover a square inch. This species and the next would probably be considered by Van den Bosch a distinct genus, differing from Microgonium by the absence of spurious venules.—Baker, loc. cit.

I have seen no specimen. Judging by description, affinity to *T. digitatum* seems probable.

20. TRICHOMANES NITIDULUM Van den Bosch. Plate 7, fig. 1.

T. nitidulum VAN DEN BOSCH, Pl. Jungh. (1856) 547; Hymen. Javan. 21, pl. 15.

T. corticola BEDDOME, F. S. India 87, pl. 264.

T. inerme VAN DEN BOSCH, Meded. v.'s Rijks Herb. No. 17 (1913) 23, fig. 12.

Fronde glabra rubro-fusca e subcordato ovata vel rotundata longe stipitata digitata, laciniis fastigiatis latis linearibus simplicibus furcatisve, e cellulis firmis opacis mediocribus rubro-fuscis contexta, soris amplis late

marginatis, indusio infundibuliformi limbo leviter undulato, stipite capillari glabrescente fronde usque triplo longiore.

Hab. ad truncos putridos Javae; in m. Gedé et Salak (mixtum cum *Craspedoneuro pallido*), ZIPPELIUS in Herb. FRANQUEV.; in m. Pangerango alt. 6000 ped., v. GESKER, JUNGHUHN. Specie forsan non different specimina Ceylonica a THWAITES lecta (N. 3278).—Van den Bosch, Hymen. Javan., loc. cit.

Fronds 1 to 2 cm long and wide, on stipes as long or longer. The segments, 1 to 2 mm wide, may be as many as 10, and more or less equal; on less developed, commonly sterile fronds, they are fewer and often quite unequal, the frond tending to be monopodial. This difference in form between ill and amply developed fronds obtains throughout the group, and indicates that the broad, flabellate form is the derived (not primitive) one. The sorus is as wide as the top of the segment, as long as wide, the straight sides forming an acute angle at the base, the mouth undulate, not bilabiate. Described as glabrescent, it bears a few caducous hairs on the stipe and margin, but most specimens are perfectly glabrous; these hairs are weak, and relate *T. palmatifidum* to this species, rather than to *T. digitatum.*

I cannot see that *T. corticola*, whether from Ceylon (*Beckett, Ferguson*) or from New South Wales (in Herb. Singapore ex Herb. Sydney as *T. digitatum*), is in any respect distinct. Between these geographical extremes, I have it from Java, Sumatra (*Bartlett 7989*), and Tonkin (*Pételot 4441*). It has been reported from Riau, Borneo, and the Philippines, in error at least as to the last.

21. TRICHOMANES FRANCII Christ. Plate 7, fig. 2.

Trichomanes Francii CHRIST, Bull. Herb. Boissier II 7 (1907) 648.
T. cuneatum CHRIST, Bull. Herb. Boissier II 7 (1907) 649.

. . . typus in herb. Bonati.

Du groupe goniocormus V. S. B., très distinct par un tissu rigide, glabre, vert et non tournant au brun. Fronde orbiculaire-flabellée, à lobes irréguliers, très courts, larges et peu profonds, le gros centre de la fronde restant indivis. Urcéoles largement triangulaires-campanulées, entièrement immergées dans le bord du lobe.

* * * * . * * *

Rhizomate tenui fere filiformi brunneo rigido nitente repente ramoso intertexto, foliis sparsis sus approximatis, stipite 1 ad 1½ cent. longo brunneo filiformi sed rigido curvato nudo, uti tota planta, lamina suborbiculata basi truncata sive cuneata 6 mill. longa 8 mill. lata, breviter flabellatim lobata, lobis irregularibus circa 5,2 mill. longis et latis integris, sterilibus rotundato-obtusis, fertilibus decussatis. linea incrassata marginatis. Costa nulla. Nervis atrobrunneis partim dichotomis partim sim-

plicibus, in lobis singulis, ante marginem incrassatis, versus marginem saepe suboccultis, venulis spuriis paucis, inconspicuis.

Urceolis viridibus 2 aut 3, in apice abcisso loborum singulis, late campanulato-triangularibus, magnis, 1½ mill. longis et latis, omnino immersis, ore recte abscisso nec labiato, margine integro, receptaculo soroque profunde immerso.

Textura crassiuscula sicce rigida, subdiaphana, colore laete virente.

Hab. Forêts humides du Mont Mou [New Caledonia] 1200 m. Très rare. F. 1906 n. 163, l. Franc.—Christ, loc. cit.

Trichomanes cuneatum, based on *Franc 165,* the type also said to be in the Bonati herbarium, was collected in the same place, and supposed to be distinguished by being somewhat larger, more deeply divided, and more delicate. The Bonati herbarium as bought by the California Botanic Garden contained no specimen of *165.* It contains *163* collected in December, 1906; very copious material bearing the same number, collected in 1910; specimens without number collected in the same place in 1907; and *828* and *2004,* which are similar but without data of collection. The 1910 collection completely blankets the descriptions of Christ's two species, growing mixed, and certainly all one plant. The margin is slightly differentiated, not thickened and without a marginal vein. And the fronds of all of the collections have turned brown with time.

It is an exceptionally distinct species.

22. TRICHOMANES VITIENSE Baker. Plate 9, figs. 1 and 2.

Trichomanes vitiense BAKER, Journ. Linn. Soc. Bot. **9** (1866) 338, pl. 8, D.

T. Powellii BAKER, Syn. Fil. (1867) 76.

Frondibus substipitatis oblongis integris vel bifidis costa centrali sola, venis lateralibus et venulis spuriis nullis, involucro solitario terminali incluso, ore integro subdilatato.

Forming close densely matted patches. Rhizome slender, wide-creeping, branched, tomentose. Stipes one to three lines long, sometimes absent. Fronds linear-oblong or oblong, usually undivided, occasionally emarginate or bifid, quite entire at the margin, furnished with a distinct midrib, but without either lateral veins or spurious venules; involucre urceolate-cylindrical, solitary, terminal, quite sunk in the frond, the slightly dilated entire mouth equalling the margin.

Fiji, *Milne.*—Baker, loc. cit.

Reported as common in Queensland and cited from Fiji, Samoa, and New South Wales, by Domin, Bibl. Bot. 20: 10, pl. 3, f. 3. Compared with *T. Motleyi* and *T. Sayeri,* Domin's figures indicate more slender fronds than Baker's, and make this and the presence of stipes the distinctions from *T. Motleyi.*

I have no specimen from Fiji, but have no reason to doubt the identity of those from New South Wales represented by Plate 9, figs. 1 and 2. The fronds are about 2 mm wide and up to 8 mm long, on stipes less than 1 mm long and, like the rhizome, notably slender. The cell walls are very thin, and hyaline. Against all lateral walls, except the marginal ones, is collected the dense contents of the cells, with the result that with low magnification the walls appear notably thick. The mouth of the involucre is hardly dilated, but the whole upper part of it is overfull and therefore folded in pressed specimens.

The absence of any veins except the costa makes this species very distinct from any other known.

While it would not be suspected from Baker's description, and I have not seen an authentic specimen, I believe that *T. Powellii* Baker is a better developed form of the same species named, in its most simple form, *T. vitiense*. The close affinity was recognized by Kuhn, Linnaea 35 (1868) 387; and the *T. vitiense* cited from Samoa by Domin must be this plant. Kuhn tried to distinguish the Samoan from the Fiji plant by the fact that the fronds are *sometimes* divided, and by thinner cell walls and a cyathiform involucre. The walls of the Australian plant are remarkably thin; Domin depicts the involucre of *T. Powellii*, and illustrates the fronds as usually simple, but sometimes forked.

TRICHOMANES ASWIJKII (sphalm. ASNYKII) Raciborski, Natuurk. Tijdg. Ned. Ind. 59 (1900) 238, pl. 2, fig. 6.

Rhizome an der Baumrinde kriechend, kurz beharrt, in Abständen von 5–12 mM. Blätter tragend, reich verzweigt, ausgedehnte, reine Rasen bildend. Blattstiel fadenförmig dünn, 1–4 mM. lang. Blattlamina bald ungetheilt, bald dichotom 1–2 mal gegabelt, glatt, ohne Scheinnerven, ganzrandig, gelbgrün, nach dem Trochnen tabakbraun. Ungetheilte Blätter linear, 2.5–5 gewöhnlich 4 mM. breit, mit einem starken Mittelnerven, an der Spitze, wenn steril ausgerandet, gegen die Basis verschmälert. Häufig kommon einmal bis zur Hälfte der Länge der Lamina oder etwas tiefer gegabelte Blätter, seltener sind noch einmal gegabelt, so dass ein Blatt in 2, 3, 4 oder sogar 5 breite Lacinien ausläuft. Die Sori apical, cylindrisch trichterförmig, eingesenkt in der Blattspitze, 3 mM. lang, mit einer breiten, runden, oder schwach zweilappigen ganzrandigen Rand des Indusiums. Receptaculum bis 8 mM. lang. An den Baumstämmen am Fuss des *Slamat*, 1200 M. hoch zusammen mit *T. sublimbatum;* sehr häufig am *Goenoeng Bintjana.*—Raciborski, loc. cit.

Except it be somewhat broader fronds or segments (4 mm as against 2 or 3 mm), there is nothing in this description to distinguish the plant from *T. vitiense;* and the discovery in Java of a plant so likely to be overlooked in the Papuan region would

not be surprising. I do not try to place the species, without seeing a specimen, however, because it must also bear a notable likeness to a reduced form of *T. nitidulum,* its neighbor in Java. Also, only the absence of rather inconspicuous false veinlets distinguishes it from the same author's *T. rupicolum.* The illustration does not show that the tube of the involucre is at all cylindric.

23. TRICHOMANES DIGITATUM Swartz. Plate 7, figs. 3 and 4.

T. digitatum SWARTZ, Syn. Fil. (1806) 370.

T. lanceum BORY ex Willd. Spec. Pl. 5: 500; HOOKER and GREVILLE, Ic. Fil. pl. 33.

T. flabellatum VAN DEN BOSCH, Hymen. Javan. 19, pl. 13.

T. Blumei HASSKARL, Observ. Bot. Fil. 2: 4.

Habitat in Ins. Franciae et Borboniae.

Descriptio

Surculi implexi, capillares, flexuosi radiculis brevissimis villosis hinc inde exsertis, reptantes.

Frondes stipitibus capillaribus semipollicaribus laxis suffultae, erectae, diaphanae, recticulatae laete virentes, digitatae (circumscriptione ovato-subrotunda); *laciniis* profunde ab invicem separatis, linearibus, erectis, subuncialibus, latitudine 2 lin., plerumque indivisae l. interdum bipartitae, apicibus obtusis subemarginatis, margine subdenticulatis, denticulis setis brevissimis adpressis terminatis.

Urceoli solitarii sub apicibus laciniarum inserti, *ore* dilatato integerrimo.

Observatio

Distinctissimum fronde digitata, urceolis insertis ore dilatato subcampanulato.—Swartz, loc. cit.

On page 422 is a more concise diagnosis, including: "laciniis . . . indivisis bipartitisve."

This is an excellent description of the species in its type locality, except only that the brownish cast characteristic of the group is not wanting here; the segments are always few, commonly 2 to 4. Exactly similar specimens can be found whereever the species occurs, but more ample ones are commoner in fruit in most such places. *Trichomanes flabellatum* van den Bosch was to be distinguished chiefly by more numerous segments, the less divided fronds in his fig. 1 being sterile; but fronds with very few segments may also be fertile, at least in most places.

Aside from the two forms just mentioned, several others are locally recognizable. It is common in the Peninsula, and not rare in the Philippines and Java, for some of the segments to be arrested in their development, while their twin segments elongate and fork again, thus producing an irregular monopodium, or a frond with several branches somewhat monopodial

in development. There is every gradation to these moderately elongate fronds and those equally long and wide. This tendency to elongate is exaggerated in a strain in western Java, resulting in fronds sometimes more than 10 cm long, which it has been convenient to distinguish specifically, as *T. dichotomum*.

A form with broad, and correspondingly few, segments, up to 3 mm in width, is occasional in the Philippines: *Bur. Sci. 9791 Robinson,* from Mount Banahao, Plate 7, fig. 4; *Bur. Sci. 37748 Ramos and Edaño,* from Bontoc. While the individual collections of this are fairly uniform, other collections fill the gap, down to those with segments at most 1.5 mm wide. In the southern Philippines, there seems to be a fixed small form: *Elmer 14125a;* but the typical form and the elongate form are also there.

Mauritius, Java, Borneo, the Peninsula and Singapore, the Philippines; apparently, also, Samoa, whence all specimens I have seen are too imperfect for certainty. Reported in many other places; but as I have seen almost every species in the group labelled *T. digitatum,* I abstain from citation by report.

24. TRICHOMANES LIBERIENSE Copeland sp. nov. Plate 9, figs. 3 to 6.

T. minutum, rhizomate filiforme ramoso intricato velutino; stipite ca. 1 mm longo; fronde plerumque ca. 6 mm longa, 3 mm lata, elliptica vel obovata, basi rotundata vel rarius cordata v. subcuneata, apice rotundata, integra vel crenulata, costata, venis utroque latere costae 5–7 simplicibus, venulis spuriis nullis, margine setis nigris nonnullis simplicibus vel binatis ornata; soro terminale, tubo cylindrico immerso, ore valde expanso exserto et libero.

Liberia, Mount Coffee, *O. F. Cook,* March, 1894. Type in *U. S. Nat. Herb. 424785.*

Very clearly distinguished by the absence of false veins and the presence of marginal hairs from all species except *T. barklianum.* From that species, known from the islands on the other side of Africa, it seems to differ in being narrower and more nearly sessile, and with a more expanded lip.

25. TRICHOMANES DICHOTOMUM Kunze. Plate 7, fig. 5.

Trichomanes dichotomum KUNZE, Bot. Zeit. 6 (1848) 285; VAN DEN BOSCH, Hymen. Javan. 22, pl. 16.

Fronde membranacea, laxa, oblonga, obtusa, flexuosa, margine setulosa (fusco-olivacea), basi in stipite decurrente, pinnata; pinnis in rhachi alata decurrentibus, furcatis dichotomisve, angulis obtusiusculis, segmentis uninervibus, lineari-oblongis, apice sorophoris, sterilibus obtusis emarginatisve;

involucris scyphiformibus, immersis, labiis liberis, rotundatis, repandis, nudis; receptaculo filiformi, emerso; stipite brevi, setaceo-filiformi, parce et minute paleaceo; caudice repente, filiformi, sparsim frondigero et radiculoso, in basi stipitum et radicularum densius rufo-paleaceo. (*Hymenophyllum* n. sp. Mor Verz.)

. . . Ex affinitate proxima *Trich. digitati* Sw. et *translucentis* mihi (l. l. p. 302) sed ambitu, textura minute oblongo-cellulosa pellucida, parietibus incrassatis fuscis, colore fusco-olivaceo ab utroque diversum. Frondes ad 5″ longae, vix 4–6‴ latae; valde flexuosae. Stipes 2–3 pollicaris, gracillimus. Statio haud dubie ad truncos, cum muscis, hepaticisque mixtum occurrit.

Java. *Zollinger 1707.*—Kunze, loc. cit.

The frond is not pinnate, but monopodial. A single main axis may develop, as described by Kunze, producing a very narrow frond; more commonly, one to several other axes also develop similarly, thus producing a variety of irregular frond forms. The same tendency of growth responsible for the elongate frond results in involucres longer than in typical *T. digitatum.*

As described by Kunze, figured by van den Bosch, and illustrated by a collection by Raciborski on Mount Salak in 1897, this seems very distinct from *T. digitatum.* However, a collection from the same region by *Bakh. v. d. Brink 2612,* "Goenoeng Jjisalak," distributed as *T. dichotomum,* is about as near to one as to the other. The tendency to this manner of growth in *T. digitatum* has been mentioned in the discussion of that species.

26. TRICHOMANES TAENIATUM Copeland. Plate 10.

Trichomanes taeniatum COPELAND in Bishop Mus. Bull. **93** (1932) 6, pl. 2.

T. dichotomo-digitatum, rhizomate gracillimo, vix 0.15 mm crasso, stipiteque simile 2 ad 3 cm longo nigris pilis paucis debilibus caducis vestitis; fronde pendente flabelliforme, 2 ad 3 cm longa et lata, pluries dichotoma segmentis 15 ad 45, sursum 1.5 ad 2 mm latis deorsum angustatis, integris vel rarius undulatis, setis nigris appressis ciliatis aliter glabris; involucris aut campanulatis aut brevi-tubulatis, ore integro late expanso, in herbario bilabiato.

Tahiti, *Grant 3561* (type), Fautaua, below Diadem, altitude 970 m; Teahupoo, *Grant 3881,* altitude 450 m, on *Cyathea; Grant 4401,* Mahina, altitude 1,070 m; *Vesco.* Borabora, *Grant 4981,* Tarapaia.

The material is not uniform. The type collection and *Grant 3881* are bright green, with narrow segments and tubular involucre. The Mahina collection has broader and less numerous

segments, is dark and turns darker, and has a campanulate involucre. I would be disposed to regard them as specifically distinct, but that the Borabora collection is between them, with broad segments but tubular involucre.

27. TRICHOMANES PALMATIFIDUM C. Müller. Plate 7, fig. 6; Plate 11, fig. 1.

Trichomanes palmatifidum C. MÜLLER, Bot. Zeit. 12 (1854) 732; VAN DEN BOSCH, Hymen. Javan. 20, pl. 14.

Cespitulosum parvulum tenellum; rhizoma repens intricatum capillare, pilis fuscis simplicibus subulatis acutis teneris hirsutulum; frons in stipite capillari *elongato* piloso *perfecte digitata, e pinnulis* 4–6 *dichotomis subaequilongis composita;* pinnulae *breves* ligulato-lineales angustae obtusatae tenerae, *margine et nervo ciliatae,* fusco-virentes, nervis capillaribus percursae; cilia *subito e folio enata subulato-filiformia longa duplicata;* cellulae pellucidiores fuscidulae ampliores hexagono-parenchymaticae teneriores; indusia in pinnulis omnibus terminalia minuta oblonga *ciliato-hirsuta.*

Tr. digitatum Blume. Enum. Filic. Javae, p. 224. excl. syn. Swartz.-Hook. Sp. Filic. I. p. 119. species Javanica.—Kunze, Recens, Hymenophyll. Hookeri. Bot. Zeit. 1847. p. 302.

Patria. Java, in muscosis truncis arborum: Blume. Zollinger Coll. No. 1722.

A praecedente (T. digitatum) signis cursive impressis certe distinguitur et pulcherrima species.—Müller, loc. cit.

Well characterized by long stipes, hairy fronds, and short sori; the sides of the involucre commonly meet at the base at an obtuse angle, so that the sorus is broader than long. The hairs are exceedingly slender, and therefore readily broken off. Judging by the considerable number of collections seen, this species is more uniformly digitate, with fronds about as wide as long, than is *T. digitatum;* which makes the comparatively elongate frond of the succeeding species quite distinct.

Java, Sumatra, the Peninsula. So little known beyond Java that it is worth while to cite collections: Sumatra, *Winkler 111.* Pahang, *Ridley, Eryl Smith 883, Md. Haniff and Nur 7879, Holtthum 20640.* Kelantan, *Md. Nur 12202.* Perak, *Scortechini.* All Peninsular collections in the Singapore herbarium.

28. TRICHOMANES RIDLEYI Copeland sp. nov. Plate 11, figs. 2 and 3.

Microtrichomanes, rhizomate stipitibusque angustissime filiformibus, stipitibus 3 ad 5 cm altis; fronde 2 ad 2.5 cm longa, dichotome ramosa segmentis paucis adscendentibus atroviridibus vix ultra 1 mm latis, margine et sparsius costis pilis ferrugineis 0.5 mm longis deciduis ciliatis; soro late obconico, vix 1 mm lato et saepius quam lato breviore, labiis late rotundatis ciliatis.

Malay Peninsula, Pahang, Gunung Talian, *H. N. Ridley 15909,* July, 1911. Type in Singapore Herbarium.

The pubescence is that of *T. palmatifidum;* the gross appearance rather that of *T. digitatum;* the stipes are too long for either, and the sori too short for *T. digitatum.*

29. TRICHOMANES LYALLII Hooker. Plate 7, fig. 7; Plate 11, fig. 4.

Trichomanes Lyallii HOOKER, Syn. Fil. (1867) 77.
Hymenophyllum Lyallii HOOKER, f., Flora Nov.-Zel. 11 (1854) 16.
T. calvescens VAN DEN BOSCH, Ned. Kr. Arch. 5^2 (1863) 199.

St. 1–2 in l., slender, filiform; *fr.* $\frac{3}{4}$–2 in. each way, suborbicular in general outline, flabellately divided down very nearly to the base into dichotomously-branched narrowly linear ciliated and minutely denticulate segments; *sori* 3 or 4, terminal on the segments; *invol.* obconical, quite sunk in the tube, the mouth ciliated, not dilated. . . .

Hab. Trees, south-west coast of the middle island, New Zealand, *Dr. Lyall.*—Hooker, Syn. Fil.

The most distinct species in the group, characterized by peculiarly toothed margins of frond and involucre. Each tooth bears a hair, consisting of a long basal cell surmounted by 1 to 3 (most often, 3) widely divergent or radiate more slender cells, these branches of the hair sometimes two cells in length. A common size of frond is 2 cm in length and breadth.

Trichomanes calvescens is absolutely identical, except, judging by the few specimens seen, for being somewhat smaller.

New Zealand and New South Wales.

This is not merely congeneric with *Hymenophyllum obtusum;* it is hardly more than a reduced form of that species, which, in small but still fertile forms, becomes more flabellate than pinnate. I am not questioning the generic position of *H. obtusum,* nor the affinity of *T. Lyallii* and *T. palmatifidum;* but am leaving *Microtrichomanes* in *Trichomanes,* until the question of generic boundaries may be studied as a whole. Compare Fournier, Ann. Sci. Nat. V 19 (1874) 292.

6. CREPIDIUM PRESL, HYMENOPHYLLACEAE, PAGE 115, AS SECTION OF DIDYMOGLOSSUM; AS GENUS, EPIMELIAE PAGE 258; NON BLUME.

Small ferns, usually notably thin, without veins, but with one or two rows of specialized, elongate, more or less thickened, marginal cells, of which the inner row (or both) may be two cells deep. Axes usually winged throughout. Sori winged, with dilated but hardly lobed mouth, occupying the first acropetal secondary segments; that is, axillary in distinction to terminal. A natural group of a few species, confined to the Malay-Polynesian area; related to the group of *T. pyxidiferum,* but without evident affinity to *Taschneria.*

Key to the species of Crepidium.

Marginal elongate cells a single row.
  Ultimate segments elongate.
    Segments narrowly cuneate .... 32. *T. endlicherianum.*
    Segments linear, sides parallel .... 33. *T. Werneri.*
  Segments mostly short and toothlike............................. 34. *T. Vieillardii.*
Marginal elongate cells in a double row.
  Rachis and involucre conspicuously winged......................... 30. *T. humile.*
  Rachis and involucre narrowly winged..................... 31. *T. gracillimum.*

Doubtful species of this section are *T. perpusillum* v. A. van Rosenburgh, *T. apicilare* Fournier, *T. assimile* Mettenius, and *T. paniculatum* v. A. van Rosenburgh.

30. TRICHOMANES HUMILE Forster. Plate 12.

Trichomanes humile FORSTER, Prodromus (1786) 84.
T. luzonicum PRESL, Hymenophyllaceae (108 nomen) 134.
T. concinnum METTENIUS, Linnaea 35 (1868) 385.
T. filiculoides CHRIST, in Schum. and Laut., Fl. Deut. Schutzgeb. (1901) 108.
T. Lauterbachii CHRIST, in Schum. and Laut., Fl. Deut. Schutzgeb. (1901) 108.

Frondibus pinnatifidis dichotomis: pinnis alternis decurrentibus linearibus obtusis integris, fructificationibus turbinato-infundibuliformibus, stylis setaceis exsertis, stipite vix ullo. F.
Societatis insulae.—Forster, loc. cit.

Rhizome creeping and interlaced, very slender, velvety. Stipe almost none, or a centimeter or more long and winged in the upper part. Frond 2 to 8 cm long, ovate if short, lanceolate or ovate-lanceolate if elongate, usually bipinnatifid, the axes winged throughout and bearing short, scattered, caducous hairs. The segments are rather remote; those immediately below the apex, and usually the basal ones, are short and simple, the medial ones forked or pinnatifid; on very ample fronds, some acroscopic secondary segments are again forked. The ultimate segments are commonly about 1 mm wide, sometimes not more than 0.6 mm; with its wing, the axis may be as wide as the segments, or distinctly narrower. The apex of a segment is usually indented, with an interruption of the marginal line, but may be rounded, with the line continuous around it. The color is usually a pale green, but varies to dark.

The most distinctive character of the species is a double row of marginal cells (as seen in surface view), elongate parallel to the margin, two to four times as long as wide, with cross walls running obliquely downward and inward from the margin. The outer wall is hyaline, with slightly thickened walls. The inner

row is thicker-walled and therefore darker, and peculiarly marked, usually by a longitudinal row of little circles, as shown by Plate 12, figs. 1 and 2. Mettenius, Hymenophyllaceae, pl. 1, figs. 28 and 29, figured this pattern, and showed that it is produced by hemispherical thickenings of the inner walls of both of two superimposed cells, this single line of the frond being two cells thick. Exceptionally, the pattern varies, the thickened spots being enlarged until the thin spaces between them present a reticulate appearance. More rarely, no pattern is visible.

As in very many species, single cells or groups of cells, presumably diseased or dead, become dark or black. In *T. humile*, this is most likely to befall the elongate marginal cells; if it happens to very many of them, the result is a black marginal line, obviously not a specific character in such cases. Fronds so bordered are common on Mount Maquiling, Luzon, as illustrated by *Copeland 2145* and *Bur. Sci. 9888 Robinson;* but occur elsewhere, as on *Grant 4941,* from Borabora, and *Grant 5297,* from Huahine.

The sori occupy the first acropetal branches of the fertile primary segments, standing parallel to the axis of the frond, remote both from this axis and from the next acropetal segment, if there be another. Rarely, on the most ample fronds, the largest primary segments (pinnæ) are sparingly bipinnatifid, and a sorus may then stand parallel to the axis of the primary segment; this is rather characteristic of Singapore specimens.

The involucre is tubular, or slightly widened upward, about 2 mm long, with a wing usually three to six cells wide, sometimes narrower, sometimes dilated at the base. The mouth is abruptly dilated; sometimes moderately, so as hardly to exceed the diameter of the tube plus its wings, sometimes considerably farther. The sclerenchyma strands running up the sides of the tube also bend abruptly outward at the mouth, but do not usually reach the margin. In end view, the mouth of fresh specimens is usually orbicular; at most, the diameter vertical to the plane of the frond is slightly the greater. A mouth so dilated is necessarily flattened and folded in pressed specimens, presenting more or less the aspect of being two-lipped. Thus Plate 85, fig. 1, of Hooker and Greville reasonably illustrates a pressed specimen; but fig. 5, purporting to represent a sorus with the near side of the involucre removed, is, as to the mouth, a figment of the imagination. Although it typifies Presl's section *Crepidium* of *Didymoglossum,* it is not at all a *Didymoglossum* in Presl's sense. Neither does it typify the same author's *Crepidomanes,* later

published as a genus, nor can it properly belong in such a genus, typified by *T. intramarginale.*

The receptacle is remarkably slender, and therefore very commonly broken. It may be two or three times the length of the involucre.

The type locality as stated by Forster is the Society Islands. After satisfying myself that *T. endlicherianum* is a distinct species, and that *T. tenue,* described from Tahiti, is like *T. endlicherianum,* it became important to know *T. humile* from the group as thoroughly as possible. Fortunately, Mr. M. L. Grant was collecting there, and brought in ample collections from Moorea, Borabora, and Huahine, as well as from several places on Tahiti. In all of these collections, as well as in the considerable number of others in hand from Tahiti, the double row of marginal cells is constant. Within the archipelago, the species is well defined, varying to but within the limits indicated in the foregoing description; as a general rule, it is rather small here, fronds more than 5 cm tall being above the average.

It is common also, and identical, in Samoa, Fiji, and Rarotonga. I have it also from the Carolines [7] (probably *T. depauperatum* Bory [8]), Papua, Amboina, Java, and Sumatra. My Hawaiian specimens received as *T. humile* are *T. draytonianum,* while those from New Zealand are *T. endlicherianum.* In Singapore and the Malay States, a more ample form, with rather narrow segments, is common. Both this and the typical form occur in Borneo, as well as one with very slender fronds. In the Philippines it is a very common species, in the typical form, and in one somewhat taller, but not wider, and without the peculiarly placed sori found in Singapore. Philippine collections distributed under other names are *Cuming 98,* the type of *T. luzonicum; Merrill 6064* and *6065; Clemens 226; Elmer 7077; Bur. Sci. 13302, 14956, 22517, 28080, 30843, 31473, 41534.* Others apparently distributed unnamed are *Merrill 6309* and *Bur. Sci. 12082.*

Trichomanes luzonicum Presl is perfectly typical *T. humile,* described under the illusion that *T. humile* was a *Didymoglossum. Trichomanes filiculoides* was published with the citations "*Lauterbach 535c, 541 . . . 988.*" The first of these, which should be the type, was apparently segregated from a mixture;

[7] *Volkens 364,* in the Singapore Herbarium as *T. rigidum,* is *T. humile.*

[8] Cf. van den Bosch, Hym. Jav. 16 and 17.

I have not seen it. No. *541* is in the University of California and Singapore herbaria, and *988* in the Singapore herbarium, and both are typical *T. humile.* It was described again in this instance as a *Didymoglossum,* and contrasted with *T. Filicula,* which indeed it does not resemble.

Trichomanes Lauterbachii Christ, published on the same page as *T. filiculoides,* as *Crepidomanes* "ex affinitate *T. pyxidiferi,*" ought by description to be a small *T. humile* with exceptionally broad fronds, typified by *Lauterbach 2825a.* I have not seen this collection; but in the herbarium of the University of California are *Schlechter 16182, 17307,* and *19072,* all received as *T. Lauterbachii.* As a whole, they conform to the description, and can be taken as correctly named; but all of them contain, along with the broader fronds, and on the same rhizomes, fronds of the typical form of *T. humile.* At most, it is a small and not well-established local form.

Trichomanes concinnum Mettenius was described from Tahiti, based on collections by Vieillard and Vesco. A Vesco specimen in the Bureau of Science herbarium is *T. humile.* As this collection is not numbered, it may or may not have been the same seen by Mettenius. Mettenius is the last author whose species in this group I would be disposed to question. However, the actual publication was after his death, and the extensive posthumous publication of his notes is responsible for no few names which so careful a student might have preferred to leave in manuscript. While he does not mention *T. humile,* a little *Trichomanes* with "series binae cellularum marginalium manifestius incrassatæ" must be that or a very nearly related species. I construe it as a very small and correspondingly little dissected, perhaps juvenile, form of *T. humile.* It is represented also by *Grant 3679,* which is surely a juvenile *T. humile.*

To *T. humile* have been reduced also *T. minutulum* Gaud., from Rawak, and *T. aureum* van den Bosch, both unknown to me save by description. The former was figured, Freycinet, Voyage, etc., pl. 12, fig. 2, as having the mouth two-lipped in a degree never simulated by any pressed *T. humile,* and its description stresses this feature. As the reduction was made by Hooker, Sp. Fil. 1: 124, who thought *T. humile* had a two-lipped involucre, I mistrust it; the reduction to *T. filicula* Desv. by van den Bosch, Synopsis 41, is more reasonable. *Trichomanes aureum* was described from New Zealand, and is more likely to be *T. endlicherianum,* if either.

31. TRICHOMANES GRACILLIMUM Copeland sp. nov. Plate 13.

Crepidium, rhachi et involucro angustius alatis, soris pinnarum majorum saepius pluribus, serie interiore cellularum marginalium male distincta, aliter T. humili simile.

LUZON, Ilocos Norte Province, Mount Palimlim, *Bur. Sci. 33383 Ramos* (type in Bureau of Science herbarium), August, 1918: Kalinga Subprovince, Mount Masingit, *Bur. Sci. 37576 Ramos and Edaño.*

A local derivative of *T. humile,* of quite distinct appearance because of the extreme narrowness of the wing on the main rachis, the bases of the secondary rachises, and the involucres. While it is effectively invisible to the naked eye, the microscope shows that this wing, two or three cells wide, persists well down onto the stipe. The ultimate segments are narrower than is usual on *T. humile,* but the peculiar appearance is due to the failure of the laminar wing to hold what width it has, as it runs down to the major axes. The tendency of sori to appear elsewhere than parallel to the main rachis is more emphasized than in the Singapore plant noted in the discussion of *T. humile.* The Mount Masingit specimen is less distinct from *T. humile* than is the type, as to the wing, but more so as to the lack of differentiation of the inner row of marginal cells.

32. TRICHOMANES ENDLICHERIANUM Presl. Plates 14 and 15.

Trichomanes Endlicherianum PRESL, Epim. Bot. (1849) 10, pl. 5. A.
T. erectum BRACK., U. S. Expl. Exped. 16 (1854) 250, pl. 36, fig. 1.
T. tenue BRACK., U. S. Expl. Exped. 16 (1854) 251, pl. 36, fig. 2.
T. Naumannii KUHN and LUERSSEN ex Christ, Engler's Bot. Jahrb. 23 (1896) 336.
T. alternans CARR., Flora Vitiensis (1873) 343.

T. (Eutrichomanes, pinnata) glaberrimum, fronde anguste lanceolata bipinnata, pinnulis lateralibus ovato-lanceolatis acutiusculis adnatis, terminalibus pinnisque superioribus apice acutiuscule bidentatis (rarius integris), rachibus late alatis, stipite (brevi) apice alato, soris subaxillaribus late alatis immersis, indusio infundibuliformi-campanulato, limbo patente, receptaculo setaceo elongato.—T. humile Endl. prod. fl. norf. 17 (excl. syn.).

Habitat in insula Norfolk (Ferdinand Bauer).

Differt a Didymoglosso humili (Trichomanes humile Forst. prod. 464) et a D. minutulo (Trichomanes (Didymoglossum) minutulum Gaudich. in Freyc. voy. 377 t. 12. f. 2) limbo indusii truncato-hypocraterimorpho nec bilabiato et inde genere. Quodsi in Aspidiaceis, Aspleniaceis aliisque Filicibus indusiatis ratio indusii ad genera distinguenda valet et sufficit, quoque in Hymenophyllaceis valere et sufficere debet. Mirum est, quod Endlicher, qui genuinum Trichomanes humile Forst. in Hook. et Grev. ic. fil. t. 85 optime delineatum vidit, specimina Baueriana non diversa esse credidit. Idem valet de Didymoglosso minutulo. Accedit quoque ad T. intramargi-

nale, sed differt absentia venulae inframarginalis, cellulis laciniisque frondis, indusio.—Presl, loc. cit.

I have seen no Bauer specimen, but have from the National Herbarium of New South Wales a collection made on Norfolk by Metcalfe in 1905, which I believe to be typical as well as topotypic. If this is correct, Presl's distinction, specific or generic, in form of mouth of involucre, does not exist. Nevertheless, the species is distinct from *T. humile*, characterized most clearly by having a single instead of a double row of elongate marginal cells. The primary segments stand at an acute angle to the main axis, making the frond narrower in general outline, in spite of the fact that its segments of every order are characteristically longer. The ultimate segments commonly widen slightly from the base to the apex, while the sides of those of *T. humile* are normally parallel. The wing of the involucre is broader, so that the mouth, as dilated (and as abruptly dilated) in proportion to the tube as in *T. humile*, does not project beyond the wing, at any rate as conspicuously as in *T. humile*. The receptacle, apparently less fragile, is even longer, three or four times the length of the tube when fully developed.

The marginal cells are commonly more elongate than in *T. humile*, even up to eight times their width. Their walls may be uniformly thickened, as described and figured by Mettenius, Hymenophyllaceae 406, pl. 1, fig. 30; but more commonly the outer wall is the thicker, especially near the junction with the very oblique cross walls.

The species which I have reduced to synonymy with *T. endlicherianum* were probably all described in ignorance of that species as distinct from *T. humile*. Van den Bosch, Journ. Bot. Néerl. 1 (1861) 350, recognized the affinity of both of Brackenridge's species to *T. endlicherianum*, but regarded them as distinguishable from it. To me, *T. tenue* looks like no more than a narrow form, with some corresponding modification in size of cells. *Trichomanes erectum* is not quite so clear a case. However, I find no structural distinctions, and those in form are reasonably associated with its reduction in size. Van den Bosch suspected it of being a small form of *T. tenue*, and so it seems to me. It is wanting in our extensive recent Fiji collections, the specimens I so determined, *Parks 20480*, Bishop Museum Bull. 59: 24, being *T. humile*. *Trichomanes tenue* is likewise wanting in our many recent Tahiti collections. Of both of these "species," I have in hand the types from the United States National

Herbarium, and cotypes from the Gray Herbarium. Their absence in recent collections is very surprising.

Trichomanes Naumannii is represented by a cotype in the United States National Herbarium. It was ill described, but the specimen is perfectly identical with that of *T. tenue.*

I have not seen authentic *T. alternans.* It was distinguished from *T. erectum* by the form (elongato-linearibus) and direction (erectis) of the segments and the obvious hyaline margin. As these are all characteristics of *T. erectum,* they cannot serve to distinguish another species from it.

The known range of the species is from the South Island of New Zealand to Norfolk, Fiji, Samoa, and Tahiti. I have already noted that specimens from New Zealand distributed as *T. humile* are all (as far as I have them) *T. endlicherianum.* They are commonly smaller than typical plants or typical *T. tenue.* I suppose that they represent *T. aureum* van den Bosch, Ned. Kruid. Arch. (1863) 208.

33. **TRICHOMANES WERNERI** Rosenstock. Plate 16.

Trichomanes Werneri ROSENSTOCK, Fedde's Repert. 5 (1908) 35.

Eutrichomanes; rhizomate longe repente, filiformi, breviter tomentoso; stipitibus 0,5-centimetralibus, tenuibus, usque ad imam fere basin alatis; laminis ovalibus, usque ad 3 cm longis, 2 cm latis bipinnatifidis; segmentis primariis fere 7-jugis, medialibus maximis circiter 12 mm longis, 5 mm latis, rhomboideo-lanceolatis, inferioribus plus minus decrescentibus; segmentis secundariis inferioribus pinnatifidis, reliquis furcatis seu simplicibus; laciniis linearibus 0,4–0,5 mm latis, simplicibus vel basalibus furcatis, apice emarginatis, margine cellulis diaphanis, linearibus, uniseriatis cincto; rhachibus costique angustissime alatis; venulis tenuibus, prope marginem desinentibus; soris immersis, infundibuliformibus, ore dilatato, undulato; receptaculo flexuoso, longissime exserto, quam indusium 12–15–uplo longiore (2,5-3 cm longo).

Nova Guinea: In monte Gelu, ad saxa, prope 'stationem' c. 1000 m alt.—leg. Dr. E. Werner VII, 1907, No. 27.

Habituell und in der Zellstruktur (vgl. den hellen Randstreifen) mit *Trichomanes humile* Forst, verwandt, unterscheidet sich *T. Werneri* von diesem durch etwa halb so breite Segmentzipfel (hier 6–7, dort ungefähr 12 Zellreihen auf der halben Breite der Lacinie) und durch das überaus lange Rezeptakulum, das bei *T. humile* die Länge des Indusium nur um das 1½ fache übertrifft.—Rosenstock, loc. cit.

The very immediate affinity of this fern is not to *T. humile,* but to *T. endlicherianum,* with which, as a species distinguishable from *T. humile,* Rosenstock seems not to have been acquainted. It is quite distinct from *T. endlicherianum* in aspect, due to the more widely divergent segments, which make the frond wider and more open; and this openness is accentuated, producing an

appearance unique in the section, by the extreme narrowness of the segments. The tube of the involucre is drawn down gradually to a point, and the dilation of the mouth is gradual, but very great. The long receptacles are wanting on the cotype in the University of California Herbarium. Microscopic examination shows scattered minute hairs on the axis, even on the middle line of the involucre.

The species has been known only from the type collection, but I find it present in *Schlechter 17304*, from the upper Djamu river, altitude 700 meters.

34. **TRICHOMANES VIEILLARDII van den Bosch.** Plate 17.

Trichomanes Vieillardii VAN DEN BOSCH, Ann. Sci. Nat. IV 15 (1861) 90.

T. jungermannioides FOURNIER, Ann. Sci. Nat. V 18 (1873) 258.

Fronde oblonga vel lineari-oblonga pinnatifida, laciniis superioribus erectiusculis approximatis, inferioribus patulis remotis sublinearibus, margine in lobos dentiformes breves obtusos patulos simplices dichotomosve abeunte, cellulis teneris inaequalibus (parvis usque magnis) flavo-aureis, marginalibus seriatis hyalinis lineari-oblongis valde elongatis, soris in laciniis axillaribus vel lateralibus late alatis cylindricis, limbo ampliato (tubo usque triplo latiore), stipite vix ultra 5 mill. longo anguste alato. Rhizoma horizontale filare intricatum atro-fusco-tomentosum; frons 4 centim. circiter longa, vix ultra 10 millim. lata gracilis tenera ex olivaceo fuscescens.

Hab. Ad caudices filicum arborescentium, Balade [New Caledonia], VIEILLARD, herb. n. 1661.—Van den Bosch, loc. cit.

I have not seen original specimens of either *T. Vieillardii* or *T. jungermannioides*, but do have very ample material, of Franc's collections, from the Bonati herbarium and from Doctor Rosenstock, which blankets the two descriptions, and might provide types for an indefinite number of other species if the numerous forms were found in separate and uniform collections. In form of frond, it is the most unstable species in the group. The appearance of the most bizarre forms is a phenomenon analogous to the proliferation of *Gonocormus,* wherein occasional pinnæ assume the stature and form of small fronds. The fronds resulting from such behavior are too diverse for definition of form.

The great majority of fronds are characterized by the presence of short, more or less triangular segments or teeth, connected by broad laminar wings. Small and sterile fronds may have a single zigzag axis, a simple vein salient at each angle entering a tooth. Fronds of normal size, 3 or 4 cm long, may be composed entirely of primary segments (or pinnæ) like the simple fronds just described. But it is also common for some

of the primary segments to elongate without producing lateral teeth, or to produce lateral segments which are also elongate; and some fronds are destitute throughout of the toothlike segments.

Except as it is widened by the laminar connection of the teeth, the wing of the axes is usually narrow. Thus it may be almost wanting on the involucre (not shown in my figures); and on the lower part of the main axis it is sometimes (rarely) obsolete, the frond thus becoming really pinnate. The marginal cells are usually very long, and their cross walls very oblique. The outer wall is exceedingly thick, either throughout, as figured by Mettenius, Hymenophyllaceae pl. 1, fig. 31, or chiefly near the ends of the cells. The inner wall is hardly thicker than that of the ordinary laminar cells. The latter are less uniform than in some species, but less various than might be expected from van den Bosch's description.

The sori of the more symmetrical fronds are placed as in *T. humile,* but usually less exactly parallel to the axis. On fronds of irregular form, they lose their regularity of position, a primary segment rarely bearing more than one sorus, or a sorus not rarely occupying an entire primary segment. The mouth is very much dilated, usually more abruptly than my figures happen to show; it is usually considerably wider than the tube with its wings.

Known from New Caledonia only; and apparently growing only on tree-fern trunks. In Franc's collections (the numbers of which are not dependable), it is represented with us by *132, 708, 830* (received as *T. Milnei*), and *2005* (as *T. jungermannioides*); also, distributed by Rosenstock, by his *41* and *135* (as *T. subhumile* n. sp., an unpublished name).

CREPIDIA DUBIA

TRICHOMANES PERPUSILLUM v. A. van Rosenburgh, Bull. Jard. Bot. Buit. II 16 (1914) 37.

Eutrichomanes, Ptilophyllum.—Planta minima, caespitosa. Stipites sparsi, usque ad ½ cm longi. Frondes oblongae, tenues, glabrae, usque ad 1 cm. longae, profunde pinnatifidae, basi cuneatae vel decurrentes. Segmenta linearia, infra segmentum terminale ca 1–4 utrinque, lateralia erecto-patentia, usque ad 5 mm longa, ca ⅔ mm lata, sat abrupte acuta, stria (venula spuria) specie marginali, pallida, continua, ornata, venis centralibus pallidis, in segmentis solitariis. Sori pauci, in segmentis superioribus terminales; indusium infundibuliforme, alatum, basi acutum, apice patente dilatatum; receptaculum exsertum.

T. Nymani *Christ* differs from this by its subtufted fronds provided with black veins and bordered by a black spurious vein.

New Guinea (*Ramu, Schlechter 14157*).—V. A. van Rosenburgh, loc. cit.

I have not seen this. It may be a distinct species, or it may be a tiny form of some better known species. Except that it is somewhat smaller still, there is little in the description to distinguish it from a juvenile *T. humile,* from *T. concinnum,* for example, which is quite certainly a small *T. humile.* It may not be a *Crepidium* at all; *T. Nymani,* with which it is compared, is a depauperate *Taschneria.*

TRICHOMANES APICILARE Fournier, Ann. Sci. Nat. V **18** (1873) 257.

Fronde ambitu lineari-ovali, pusilla, vix 2″ longa, e rhizomate repente gracili enata, pinnata, pinnis linearibus simplicibus v. rarissime bifidis 2–3-jugis, venula spuria marginali instructis, in rhachidem alatam et in stipitem brevem marginatum decrescentibus, soris lacinias terminantibus, columella breviter exserta, ore integro.

Secus ripas cataractorum pr. *Wagap* [New Caledonia] (*Vieill. 2165* part.).—Fournier, loc. cit.

TRICHOMANES ASSIMILE Mettenius, Linnaea **35** (1868) 386.

Rhizoma tenerum; folia membranacea, flavo-viridia in costis nervisque pilis minutissimis obsita tripinnatipartita, hinc inde e medio petiolo s. e rhachi prolifera; petiolus ad 1½″ longus superne compresso marginatus pilis paleaceis setosus, rhachis alata; lamina 2½″ longa, 1″ lata oblongo-lanceolata; laciniae primariae patentes ovatae, infimae deltoideo-ovatae; secundariae late obovatae, ultimae lineari-oblongae, emarginatae, inferiores bifidae; nervi Caenopteridis; cellulae parenchymatis polyedricae, parietibus lateralibus plicatim incrassatae; sori axillares, immersi; indusium late alatum s. cylindricum ore ampliatum.

Novae Hebrides. Aneitium. (Herres n. 53.)

Praecedenti speciei [T. concinnum] proximum, sed foliis tripinnatipartitis, laciniis primariis sessilibus ovatis diversum. Affine etiam *Tr. prolifero* Bl. en. 224, a quo differt rhachi tereti s. compressa, laciniis primariis confluentibus. (K.)—Mettenius, loc. cit.

Referred to *Crepidium* because said to be near to *T. concinnum.*

TRICHOMANES PANICULATUM v. A. van Rosenburgh, Bull. Jard. Bot. Buit. II **16** (1914) 38.

Eutrichomanes Trichomanopsis? Tr. humile Forst. subsimile sed: Frondes majores, usque ad 7½ cm longae et 4 cm latae, 3-pinnatifidae vel sub-4-pinnatifidae, rachide primaria exalata, marginibus leviter sed distincte crispato-undulata; sori in planta adulta copiosi, in pinnis et pinnulis superioribus terminales, in pinnulis inferioribus axillares, in parte superiore frondis paniculati.

Plants with the lower pinnae resembling small specimens of T. humile *Forst.,* especially by the intramarginal spurious vein and sparingly glan-

duloso-fibrillose ribs but distinguished by the paniculate higher sori, and more or less crisped laciniae.

Java (*Klappa Noenggal,* C. A. Backer No. 5837).—V. A. van Rosenburgh, loc. cit.

Without seeing an authentic specimen, I cannot decide whether this is a form or relative of *T. humile,* or of *T. bilabiatum.*

7. TASCHNERIA; THE GROUP OF TRICHOMANES BIPUNCTATUM

Small ferns, usually epiphytic, with filiform, hairy rhizomes; fronds pinnate in plan, or in a few species becoming digitate by reduction, all or all but the strongest axes winged; false veins (*striae,* of Prantl) always present; involucre tubular or funnel-shaped, the mouth usually bilabiate, sometimes radially expanded, rarely truncate. The Old World Tropics, to Japan and New Zealand.

Presumably derived from the group of *T. pyxidiferum,* from which this group is distinguished by the presence of the false veins; with exceptions, *Taschneria* is distinguished further by the strongly bilabiate involucre. The striate species with simple or merely lobed fronds, *Didymoglossum,* are probably derived from *Taschneria* by reduction.

The false veins are critically important in the recognition of the group, and in minor degree in the discrimination of the species. This distinction of the species is difficult, first because they are much alike and variable, second because the false veins have been ignored in describing a number of them, and third because undue importance can be and has been attached to them. Hooker and Baker solved the difficulty by making *T. bipunctatum* (as *T. Filicula*) include all *Trichomanes* of the same general aspect with bilabiate involucre, including some species not even in this group. Van den Bosch used the other easy method, setting up many species, each known by one plant. Neither method has any merit except ease.

I have come positively to the conclusion that the evolution of a large part of the supposed species has been local. To illustrate: The Javan forms and the Philippine forms are distinct phyletic entities, and neither of these phyla is represented in India or in Polynesia or in Japan. In Java, van den Bosch distinguished three species, and his successors have added to the number. Likewise in the Philippines, several species have been described. A species must be a phyletic unit, whether this be large or small, uniform or varied. A species cannot comprise

phyletically distinct plants, however similar they may be, even to the point of apparent identity, unless it be so broadly conceived as to include the phyla they represent, back to the point of common ancestry. Purging it of such elements as *T. draytonianum,* which is not a *Taschneria, T. bipunctatum* might be a species including the whole group—but to-day's botanists do not tolerate such a species as it would then be.

To keep the number of species within bounds, and the species themselves in some measure describably distinct, but insistently restricting a specific name to a phyletic unit, I recognize one common species in Java and one common species in the Philippines. With as ample material, I suspect that the same course would seem proper in India. I am not at all satisfied as to what is in the Peninsula, and remain baffled rather than enlightened by the wealth of material in the Singapore Herbarium.

Unlike *Trichomanes* as a whole, *Taschneria* impresses me as a group in active evolution; and it is not in the nature of the case that the species of such a group should be clearly and uniformly distinct.

Besides *Didymoglossum anomalum,* which my more complete acquaintance with the Philippine ferns has enabled me to recognize as a dwarf of *T. brevipes,* there are a number of other species based on minute specimens. In spite of the evident fact that *Hemiphlebium* and *Microtrichomanes* have found a place in nature, I believe, analogous to the inability of dwarf races of men to hold their own in competition with races of the normal human size, that the chances are very strongly against the local evolution of any established dwarf race of *Taschneria* from the already small species of the common range in size. I believe rather that these minute supposed species represent either individuals fertile before they achieve the strength to produce the fronds of the same species in its fuller development—as happens well throughout the genus; or plants stunted by the environment, acting on the individual plants—as I know that an unfavorable change can cause a rhizome which has been producing normal fronds to produce a crop of much reduced, but fertile fronds; or plants growing from spores which germinate where the conditions do not permit the normal development of the species. A dwarf species might become fixed, in adaptation to such conditions; *T. latemarginale* may be an example. But, as long as such "species" are known by very few individuals, it remains probable that they represent other species, more of the character typical of the group.

Species described as minute and relatively simple are *T. intramarginale, T. latemarginale, T. rupicolum, T. Nymani, T. acuto-obtusum, T. palmifolium, T. pervenulosum,* and *T. minimum,* the last reducible to *T. bilabiatum.*

Because of its geographic range, far wider than that of any other species; because it is constant in the manifestation of reasonably characteristic form, structure, and—as compared with other species—size; because most other species are easily regarded as variants from the basic structural plan of this one; and because occasional plants referable as individuals to this one are found in many places where some one of the species construed as derived from this is dominant (atavism, reasonably to be expected), I regard *T. bipunctatum* as the oldest species of the group, and all others as derivatives from it. In the degree of departure from type, the sequence is roughly the population of: 1, the Malay Peninsula; 2, Java; 3, the Philippines, and 3*a* Papua; 4, the Indo-Sino-Japanese region. This sequence is not a phyletic one; except possibly as to 3 and 3*a*, and as 3 may be derived through 1, the forms of each area are regarded as independent derivatives from the common parent.

Key to the species of Taschneria.

Fronds of normal size, 3 to 10 cm tall, at least bipinnatifid.
  Submarginal false veinlet continuous, other striæ few or none.
    Marginal laminar cells in 2 regular rows........ 35. *T. bipunctatum.*
    Marginal laminar cells in one row................ 44. *T. intramarginale.*
  Submarginal veinlet interrupted, other striæ present.
    Mouth of involucre bilabiate.
      Segments commonly 0.8 to 1.1 mm wide, lips not very fibrous; Dutch Indies.
        Lips distinctly shorter than tube............ 36. *T. bilabiatum.*
        Lips about as long as tube..................... 37. *T. Rothertii.*
      Segments narrower, much fiber in lips.
        Lamina full of false veinlets; Papua.... 41. *T. venulosum.*
        Accessory striæ comparatively few; Philippines. 39. *T. brevipes.*
    Mouth widely dilated, not bilabiate........................ 40. *T. Christii.*
  Submarginal veinlet mostly obsolete; India to Japan. 47. *D. latealatum,* etc.

Dwarf forms, mostly digitate or pinnatifid.
  Intramarginal false veinlet present.
    Marginal laminar cells in one row.
      Frond monopodial; Ceylon.................... 44. *T. intramarginale.*
      Frond pinnatifid; Papua.. 42. *T. Nymani.*
    Marginal cells in two rows.
      Segments narrowly oblong; Asia............ 45. *T. latemarginale.*
      Segments broadly oblong; Java........................ 38. *T. rupicolum.*

Intramarginal strand obsolete.
Mouth dilated, hardly bilabiate .... 43. *T. pervenulosum.*
Mouth strongly bilabiate.
Tube short .... 48. *T. Makinoi.*
Tube long .... 46. *T. megistostomum.*

35. TRICHOMANES BIPUNCTATUM Poiret. Plate 18, figs. 1 to 4.

T. bipunctatum POIRET, in Lamarck, Enc. **8** (1808) 69.

Hymenophyllum alatum SCHKUHR, Krypt. Gewächse (1809) 133, pl. 135b. non Swartz.

H. Filicula BORY, in Willd., Sp. Plant. **5** (1810) 528.

Trichomanes Filicula BORY, Dup. Voyage 1 (1849) 258.

Taschneria Filicula PRESL, Epim. (1849) 258.

Trichomanes punctatum CHRIST, non Poiret, Bot. Jahrb. **23** (1896) 336.

Trichomanes frondibus subtripinnatis, membranaceis pellucidis; foliolis subdecurrentibus; pinnulis pinnatifidis; laciniis linearibus, obtusis; fructificatione prìmò bipunctatâ dein subinfundibuliformi; columellâ exsertâ.

C'est une plante basse, haute de deux à trois pouces.

. . . Madagascar, par M. Aubert du Petit-Thouars.—Poiret, loc. cit.

Stipes 2 to 3 cm long, terete, hairy and dark at the base, winged in the upper part, rachis winged throughout, narrowly in the lower part; frond 5 to 8 cm long, lanceolate or ovate, tripinnatifid, segments 0.5 to 0.8 mm wide where bearing a single vein, up to 1 mm wide above the forking of the vein and up to the forking of the frond, clear or deep green, obtuse; false vein almost continuous, separated from the margin by two rows of laminar cells, other striæ absent or rare; sori occupying the lowest acroscopic pinnules or segments, involucre 2 mm long, tubular, slender, winged, conspicuously bilabiate, the lips commonly as long as wide, triangular, acute or somewhat obtuse, erect to flatly expanded; involucre expanded.

(Madagascar). Comores, *Hillebrandt.* Bourbon. Mauritius, *U. S. Nat. Herb. 593149 Mrs. N. Pike.* Common in Polynesia: Tahiti, *Vesco, Brackenridge, Setchell and Parks, MacDaniels, Grant.* Tahaa, Huahine and Moorea, *Grant.* Rarotonga, *Parks.* Samoa, *Brackenridge, Reinecke, Whitmee.* Fiji, *Brackenridge, Prince, Parks, Horne.* Admiralty Islands, *Moseley* (mixed with *T. humile*). Vanicolla. New Zealand. New Caledonia, *Balansa 2697, le Rat 2890, Franc 428;* but *Balansa 69* in the Bureau of Science herbarium is intermediate between this and *T. venulosum.* Reported from Queensland, whence my only specimen so named, *Simmonds,* is distinct.

From New Guinea, I have no specimen referable to this species in any strict sense. *Trichomanes bipunctatum* var. *nana sub-*

flabellata Christ, *Lauterbach 914*, is a sterile dwarf, which might represent any species in the group. *Trichomanes bipunctatum* var. *venulosum* Rosenstock is better treated as a distinct species, to which I refer other collections. Neither do I find *T. bipunctatum* in India, China (except Hainan), or the Philippines, from all of which many specimens have been given this name (or *T. Filicula*).

The condition in the Peninsula is peculiar. Very many specimens are *T. bipunctatum*, very nearly, differing only in being smaller, commonly 2.5 to 4 cm tall exclusive of stipe, and in being likely to have a very few striæ besides the intramarginal false vein, or to have the latter more broken than is typical. The distinctions are not such as to make specific recognition practical, and I have therefore decided to regard *T. bipunctatum* as the dominant representative of the group here, as *T. bilabiatum* is in Java and *T. brevipes* in the Philippines. This form ranges north to Hainan: *Eryl Smith 1400*.

In Sumatra and Borneo, under these conditions, a mixture is to be expected, and is found. Of Borneo specimens, *Clemens 9955* and *Topping 1806* from Kinabalu, and *Brooks 170* (October 1, 1909) from Sarawak, are passable *T. bipunctatum*. *Brooks 23* (September, 1908) is a specimen which, like the fish in the Arabian Nights, combines the fine features of all its relatives; it has the stature of a large *T. bilabiatum*—12 by 6.5 cm—the aspect (broad, compact frond with narrow segments) of *T. Christii*, and the lips and venulation of *T. bipunctatum*. *Topping 1600* has rounded lips. *Hose 729* has almost linear lips like a Mindanao relative of *T. brevipes*.

Of Sumatra specimens, *Burchard 129*, *Winkler 175*, *Bartlett 7745*, *7746*, *7676*, *6405*, *6725*, and *7048*, and *Mousset 2206* are referable to *T. bipunctatum*. As to Java, van den Bosch's plate 26, *Didymoglossum Filicula*, represents this species more perfectly than any specimen I have seen except one from Kota Batoe by *Raciborski*, but *Bakh. v. d. Brink 557*, *5923*, and *6270* can bear this name. They are all from comparatively low country, at most 550 m altitude, while *T. bilabiatum* is a plant of the high mountains. The specimens cited by van den Bosch, however, are montane. I do not know whether any Java specimens are really *T. bipunctatum*, or whether those which might be are aberrant *T. bilabiatum*.

With the exception of the Peninsula, where I am afraid that I have left this a "collective species," the only place from which

I have been able to study enough material to show its variability is Tahiti. The ample collections of Setchell and Parks and Grant show that it produces fertile dwarfs, not open to reasonable construction as specifically distinct, such as are responsible for the improper description of species throughout the genus. *Setchell and Parks 290* contains fertile fronds only 12 mm long.

Among the Peninsula collections, in *Henderson 10700*, no individual frond of which is more than 2 cm long, I find a fertile frond 10 mm long by 7 mm wide.

36. TRICHOMANES BILABIATUM Nees and Blume. Plate 18, figs. 4 and 5.

T. bilabiatum NEES and BLUME, Nova Acta 11 (1823) 123, pl. 13, fig. 2; BLUME, Enum. 226.

Didymoglossum Filicula VAN DEN BOSCH, Hymen. Javan. 35, pl. 26?

D. laxum VAN DEN BOSCH, Hymen. Javan. 37, pl. 27.

T. capillatum TASCHNER, Diss. (1843) 34, pl. 1, figs. 2, 4, 6.

Didymoglossum capillatum VAN DEN BOSCH, Hymen. Javan. 38, pl. 28.

T. bilobatum V. A. VAN ROSENBURGH, Bull. Jard. Bot. Buit. II 20 (1915) 24.

T. minimum V. A. VAN ROSENBURGH, Bull. Jard. Bot. Buit. III 2 (1920) 175.

Tr. frondibus pinnatis, pinnis ovatis bipinnatifidis decurrentibus, laciniis linearibus bifidis obtusis integerrimis, soris supraaxillaribus ore bilabiato, rachi stipiteque alatis.

*   *   *   *   *   *   *

Descr. Caudex crassitie fili lintei fortioris, repens, ramosus, setulisque densis patentibus fuscis hispidus. Stipes octo lineas longus, compressus, ala membranacea tenui ad basin decrescente cinctus. Frons pollicem unum ad duos longa, cordato-ovata, tenuis, lutescens, pinnata. Pinnae in alam racheos angustam confluentes, 6–8 lin. longae, patentes, alternae, ovatae, acutae, pinnatifidae, planae. Laciniae cuneiformes, inferiores pleraeque iterum pinnatifidae, superiores pinnarumque maxime fertilium plurimae tri- vel bifidae. Lacinulae lineares, bifidae integraeve, omnes integerrimae, nervo medio saturate viridi lineaque haud procul ab utroque margine decurrente notatae, laxe reticulatae. Sorus pinnularum laciniae inferiori et superiori immersus, hinc subaxillaris, et Indusio, (quod appellamus,) cuneiformi, compresso alaque membranacea cincto sessili apice bivalvi totus reconditus. Valvulae, ex indusii margine ortae, dehiscentes, ovatae, obtusae, indusio plus duplo breviores. . . .—Nees and Blume, loc. cit.

Distinguishable from *T. bipunctatum* by less regularity of the spurious venation, the submarginal venule being interrupted and irregular, and other, shorter, commonly oblique and irregular striæ being present. Also, the lips of the involucre are usually obtuse or rounded, and the segments of the frond are commonly broader, 0.8 to 1.1 mm in width. The involucre of robust fronds is likely to be 3 mm long, tubular, and broadly winged.

Exceedingly variable, whence the number of names, all applied to Javan types. I have not seen the type collections of *T. bilobatum* and *T. minimum*, but there is nothing in the description of either which is not to be found in the collections in hand. *Trichomanes bilobatum* should be without the submarginal false vein; I find this true of a part of the fronds of *Palmer and Bryant 726* and *Yates 2997*. *Trichomanes minimum* is a small form, without accessory striæ. By definition, it would be *Didymoglossum anomalum*, the corresponding dwarf of *T. brevipes;* but it is certainly more reasonable to refer it to the normally larger Javan species.

Beyond Java, I refer to this species an unnumbered *Burchard* plant and *Bartlett 6538*, from Sumatra. A number of specimens from the Peninsula are like *T. bilabiatum*, but I can draw no definite line there between these and those referable rather to *T. bipunctatum*. It is a curious fact that still farther north specimens recur which are like *T. bilabiatum* in all respects except narrower segments—*Eberhardt*, from Hanoi, and *Pételot 4074, 4075* from Chapa, all from Tonkin.

Werner 18 and *Schlechter 17304*, from Papua, distributed as *T. bilabiatum* might be this species if from Java, although there is more sclerenchyma in the lips; but they are small plants, and I believe that this is the reason there is less sclerenchyma in the lamina than in the larger plants from the same collectors, *Werner 60* and *Schlechter 16370*, which are referred to *T. venulosum*.

37. TRICHOMANES ROTHERTII v. A. van Rosenburgh.

Trichomanes Rothertii v. A. VAN ROSENBURGH, Bull. Jard. Bot. Buit. II 1 (1911) 13.

Eutrichomanes, Ptilophyllum.—T. humili affine sed venulis spuriis marginalibus carentibus, et venulis spuriis accessoriis inter marginem et costulas copiosis, erecto-patentibus, irregulariter sparsis praesentibus.

Differs from T. humile by the absence of the marginal spurious vein and the presence of numerous erecto-patent, irregularly scattered spurious veinlets between the margin and central veins. Fronds ovate in general outline, up to 5 cm. long, to 2 cm. broad; veins 1 in each ultimate segment, not reaching the apex of the segment, naked or provided with minute, distant, fibril-like scales. Sori solitary on the upper side of the primary segments at the base, or on both sides of them; tube with the mouth hardly dilated, conspicuously 2-lipped, the lips triangular, erect or somewhat spreading.

Java (Preanger Regencies, Dr. W. Rothert.)—V. A. van Rosenburgh, loc. cit.

The foregoing diagnosis is obviously in error, because no fern with nonmarginate fronds, and with many oblique false

veinlets, can be located by affinity to *T. humile.* I have not seen an original specimen, but find in the herbarium of the Singapore Botanical Garden a specimen, *Holttum 15479,* collected at Brastagi, Sumatra, identified as this species, and conforming to what there is of a description. It is an immediate relative of *T. bilabiatum,* distinguished by smaller size and large, narrow, divergent lips. The lips are about as long and wide as the tube. Plants with similar sori in Mindanao and New Caledonia are derivatives, respectively, of *T. brevipes* and *T. bipunctatum.*

38. **TRICHOMANES RUPICOLUM** Raciborski. Plate 19, fig. 2.

Trichomanes rupicolum RACIBORSKI, Pterid. Buitenzorg (1898) 24.

Rhizom kriechend, sehr dicht abstehend behaart, mit der Behaarung 0.5–1 m.m. dick. Blattstiele fadendünn, 1–3 m.m. lang, mit wenigen Haaren bedeckt, fast nackt. Lamina bis 1 c.m. breit und lang, im Umriss gewöhnlich verkehrt dreieckig, gegen die Basis verschmälert oder etwas abgerundet, an der Spitze im sehr wenige (3–5, gewöhnlich 3) kurze oder längere, 2 m.m. breite, bis 1 c. m. lange, ganzrandige durchsichtige, lebhaft grüne an der Spitze flach abgerundete Lacinien fingerförmig getheilt. Nerven mit kurzen, spitzen Schuppen zerstreut besetzt. Neben dem Blattrande, in unterbrochenen Zügen verlauft ein Randnerv. Sori gewöhnlich einzeln auf einem Blatt, conisch, von der Blattlamina umsäumt, an der Mündung sehr stark erweitert, und mit tellerförmigen Lippenrand über den Laminarand hervorragend, bis 1.2 m.m. breit (an der erweiterten Mündung), bis 2 m.m. lang.

Von anderen javanischen kleinen Trichomanes-Arten durch äusserst kurze Stiele und Vorhandensein der Randnerven verschieden. An den beschatteten vulkanischen Felsen am G. Pantjar, in der unteren Waldzone.—Raciborski, loc. cit.

Of this species, the Bureau of Science herbarium at Manila contains ample material of Raciborski's, presumably the type collection. It is what should be expected from the extreme reduction of *T. bilabiatum,* with one notable feature that the involucre is obconic, with immersed tube, rather than elongate with winged tube, being more like that of *Microtrichomanes* than of *Taschneria.* As the same modifications have been undergone in the reduction to *T. latemarginale,* they may be regarded as mechanical incidents to extreme shortening of the frond.

A part of the fronds, and these the largest and most likely to be fertile, are pinnate in architecture; others are apparently digitate. The false veinlet is irregular, much or little interrupted; separated from the margin by two rows of laminar cells, or less often approaching the margin, the same veinlet wandering to and from the margin; accessory striæ can be detected in a few fronds; traces of the false veinlet are present in some, but not in all, lips of the involucre. The involucre is

not really bilabiate, but the mouth is more expanded at a right angle to the plane of the frond than in that plane.

Apparently, known only by the type collection.

Trichomanes Aswijkii Raciborski, which I have not seen, must be very like *T. rupicolum* in gross aspect, but the brownish color of dry specimens and the absence of false veinlets establish its affinity to *T. nitidulum*, a *Microtrichomanes*.

39. **TRICHOMANES BREVIPES Baker. Plate 20.**

T. brevipes BAKER, Syn. Fil. (1867) 84.

Didymoglossum brevipes PRESL, Hymen. (1843) 139; VAN DEN BOSCH, Hymen. Javan. 38.

D. undulatum PRESL, Hymen. (1843) 140.

Trichomanes bilingue HOOKER ex J. Smith in Hooker's Journ. Bot. 3 (1841) 417, nomen.

T. melanorhizon HOOKER, Sp. Fil. 1 (1844) 140; Ic. Pl. pl. 705.

Crepidomanes intramarginale PRESL, Epim. (1849) 258, as to the Luzon plant only.

Didymoglossum anomalum VAN DEN BOSCH, Ned. Kruid. Arch. 5 ' (1863) 140.

D. fronde breviter stipitata oblongo-lanceolata acuta pinnata, pinnis subsessilibus oblongis obtusis profunde bipinnatifidis glaberrimis, infimis horizontalibus, laciniis oblongo-lanceolatis obtusis, secundariis (lacinulis) linearibus obtusis integerrimis, soris exsertis sessilibus, indusio infundibuliformi alato-marginato, limbi laciniis subrotundis, rachi superne alata, inferne stipiteque subnuda pubescente.

Habitat in insulis Philippinis, verosimiliter in insula Luzon, unde retulit clar. Cuming et aliis plantis immixtum sine numero communicavit.

Rhizoma longe repens, teres radicibusque ramosis paleis piliformibus densissimis nigricantibus tomentellum. Stipes duas-tres lineas longus, pilis brevibus horizontalibus pubescens, in fronde fertili teres nudus, in fronde sterili duplo minori basi teres apice alatus. Frons fertilis semiquartum, sterilis vix duos pollices longa, utraque ex ovata basi oblongo-lanceolata acuta pinnata excepta racheos basi glaberrima. Pinnae quinque-septemlineales, subsessiles, profunde bipinnatifidae, obtusae, in fronde sterili oblongo-lanceolatae, in fertili oblongo-ovatae, infimae horizontaliter patentes, omnes approximatae. Laciniae primariae oblongo-lanceolatae obtusae, secundariae anguste lineares obtusae integerrimae. Rachis frondis fertilis inferne teres pubescens, superne alata, frondis sterilis undique alata basi pubescens. Costa tenuissima, flexuosa. Venae pinnatim exorientes, pinnatim ramosae, venula in qualibet lacinia secundaria (lacinula) unica apice libera. Parenchyma e cellulis rotundato-hexagonoideis minutis constructum. Sori in suprema parte frondis obvenientes, exserti, sessiles, pauci. Indusium lineam longum, infundibuliforme, angustissime alato-marginatum, limbo bipartito, laciniis subrotundis conniventibus integerrimis. Receptaculum setaceum, indusio longius, integrum non visum, basi capsuliferum.

Valde affine D. Filicula, differt brevitate stipitis, figura pinnarum magis approximatarum et directione inferiorum, brevitate indusii evidentius pe-

dicellati et latius alati, laciniis secundariis angustioribus integerrimis.—Presl, loc. cit. (1843).

This is followed immediately by the publication of *Didymoglossum undulatum* Presl, Hymen. (1843) 140, represented as without false veins, and with broad undulate wings on rachis and stipe, and narrower fronds. Since Presl had denied the reality of the false veins, in a supplementary comment on *D. brevipes*, mistaking them for folds or wrinkles, he consistently maintained his error in dealing with the second species. In Christensen's Index, *D. brevipes* is reduced to *T. bilabiatum* and *D. undulatum* to *T. bipunctatum*. Only an examination of the Presl types can settle their identity beyond question, but I have practically no doubt that they are one species. They are cited alike as based on a mixed collection, without number, by Cuming. Fronds fitting both descriptions, with allowance for Presl's error as to the false veins, are included in *Cuming 2*, from Luzon. As was recognized by Smith, *Cuming 2* and *316*, the latter from Leyte, are one species. *Cuming 316* is the type collection of *T. melanorhizon* Hooker.

As noted by van den Bosch, Hymen. Javan. 38, it is near *T. bilabiatum*, but distinguishable by being more lax, with narrower segments, commonly 0.5 mm or less in width; it is usually smaller, and with fewer false veins. Presl, though denying their reality, characterized these very well, as most irregular in their occurrence. A single submarginal one, as described by van den Bosch, is rarely if ever present. While not abundant in the lamina, their development in the lips of the involucre is conspicuous. Here they may form solid plates, or may be largely in strands separated by ordinary cells; but in most cases they make up a considerable part of the tissue of the lips.

The genus *Crepidomanes* was based on Hooker and Greville, Ic. Fil. pl. 211, which supplied the specific name; on *Cuming 150;* and a larger Javan specimen not further identified. The last should be the plant recently renamed *T. minutum* (see *T. bilabiatum*).

The real *T. intramarginale* is a Ceylon dwarf, with very different sorus. *Cuming 150* was not named by Smith, who had an imperfect specimen. The specimen in the Gray Herbarium is presumably better, and permits recognition as a dwarf identical with *Cuming 2*. My guess is that both were collected in Laguna Province, as was also the Brackenridge plant recognized by the collector as *T. melanorhizon*, but later described

as *D. anomalum;* the last and *Cuming 150* are identical in detail. *Crepidomanes* as a genus has priority of position on the page over *Taschneria.* Also, it is characterized, while *Taschneria,* merely named with a species, is doubtfully published. If the group be raised to generic rank, distinct from *Trichomanes* and *Didymoglossum,* its name is therefore *Crepidomanes;* but for it as a group or section, without formal status, *Taschneria* is preferable, typifying it by a normally developed plant instead of a dwarf, and by the first-named and most typical species.

Didymoglossum anomalum is the named dwarf form of this species, *Cuming 150* having escaped by misidentification. These dwarfs occur throughout the Archipelago, and must not be construed as varieties. The most extreme case is *Elmer 9625,* from Negros, which has no frond more than 5 mm long, but several of them fertile. It is absolutely identical in structure with *Ridley 15700,* from Kedah, which I call *T. latemarginale* (= *T. nanum* van den Bosch, = *T. Kurzii* Beddome); but I entertain no doubt that it is a local derivative of *T. brevipes,* nor that the similar continental plants are local derivatives of their normally larger neighbors.

Trichomanes brevipes is very common throughout the Philippines and represented in herbaria by at least fifty collections. As these are mostly distributed as *T. bipunctatum,* which I do not recognize in the Philippines, it is unnecessary to enumerate them. Like its relatives, it is exceedingly variable. There are also recognizable local forms, but these are not distinct enough to merit specific recognition. *Cuming 316,* the type of *T. melanorhizon,* from Leyte, represents one of these, most similar in aspect to *T. Christii.* The most distinct such form occurs, along with more typical plants, in Mindanao, and has narrow lips of the involucre about twice as long as wide. I do not name and describe it, because I know just such forms derived from *T. bipunctatum* and *T. bilabiatum,* and prefer not to be responsible for a series of "species" exceedingly similar but distinct in phylogeny.

Beyond the Philippines, I construe two specimens from Guam as this species. *Topping 1813,* from Mount Kinabalu, is this, rather than *T. bipunctatum.* As it is the species most nearly like *T. venulosum,* of Papua, it is reasonable to expect it to be found in Papua. Also, as it is found in the Batanes, I think it probable that the plant reported in Formosa as *T. bipunctatum,* which I would not expect to find there, is really *T. brevipes.*

40. TRICHOMANES CHRISTII Copeland. Plate 21.

T. Christii COPELAND, Philip. Journ. Sci. 1 (1906, Sept.) Suppl. 251, non CHRIST, Bull. Herb. Boiss. II 6 (1906, Nov.) 988, nec ROSENST., Bull. Jard. Bot., Buit. II 2 (1911) 27.

T. recedens ROSENST., Meded. Rijks. Herb. Leiden 11 (1912) 2.

T. microlirion COPEL., Philip. Journ. Sci. 10 (1915) Bot. 146.

T. brevipes C. CHR., Gard. Bull. Straits Settlements 4 (1929) 377, non Baker.

Rhizomate late repente, 1 mm. crasso; stipitibus tenuibus, ca. 1 cm. altis, pilis brevissimis paucis pubescentibus; fronde 5–8 cm. altis, 25–35 mm. latis, acutis, tripinnatifidis; rhachi sursum anguste alata; pinnis oblongis, obtusis, infimis diminutis; segmentis integris, linearibus; urceolis infundibuliformi-campanulatis, anguste alatis alis saepius sub limbo evanescentibus, limbo leviter elato, subbilabiato, receptaculo incluso.

[Philippines:] MINDORO, prope fluminem Baco. *Merrill 1819.*

Near *Trichomanes pyxidiferum* and *T. bipunctatum*, easily recognized by the comparatively large frond and short stipe, and included receptaculum.—Copeland, loc. cit.

Christ two months later published a diagnosis independently, basing it on a specimen collected in Rizal by Loher. Details of difference are: "Rhizoma tenue;" "stipite 4 cm. longo;" "rachi omnino exalata;" "fronde 10 cm. alta;" "urceolis 1 mm. longis campanulatis bilabiatis, labiis dilatatis, receptaculo subexserto." If correct, Christ's description applies to a specimen of *T. brevipes.*

A species exceptionally distinct in this group of ill-defined species, recognizable by the broadly expanded but not bilabiate lip of the involucre. It is an epiphyte, commonly long-creeping on slender branches of shrubs and trees, with black-hairy rhizomes, fronds usually remote, short-stiped, broad, ample but compact, with many slender segments, commonly 4 to 6 cm long and 2.5 to 4 cm broad, the lowest pinnæ reduced or not so; false veinlets not strikingly developed, commonly with a much-interrupted and irregular submarginal strand, like that of *T. bipunctatum* in position, and with or without a few minor striæ; sori restricted to the apical part of the frond, sometimes so strictly as to produce a paniclelike or racemelike inflorescence in which no sterile segments occur.

In aspect of frond, this is somewhat similar to the form of *T. bilabiatum,* pictured as *Didymoglossum laxum* by van den Bosch, Hymen. Javan. pl. 27. The affinity, however, is rather to *T. brevipes,* and to the form of that species which is *T. melanorhizon* Hooker, from which it is distinguished by the form of the involucre and the weak development of fiber cells in the

mouth. I suspect that they are near enough together to hybridize in Leyte.

The range is from the central Philippines south to Mindanao, west across Borneo to Sumatra, north along the Peninsula, to Siam. As the species is not well known and has been confused with *T. bilabiatum,* I cite the collections in hand.

MINDORO, the type. POLILLO, *Bur. Sci. 10290 McGregor.* NEGROS, *Copeland s. n.* SAMAR, *Bur. Sci. 24837 Edaño.* LEYTE, *Bur. Sci. 41743, 41750 Edaño, Wenzel 425.* MINDANAO, *Elmer 14020, Merrill 8009, Bur. Sci. 36844, 36967 Ramos and Edaño.* PALAWAN, *Merrill 7268.* BORNEO, *Brooks 172,* the type of *T. microlirion;* several unnumbered collections by Brooks, and Brooks and Hewitt; *Boden Kloss 18693.* SUMATRA, *Rahmat 318.* SINGAPORE, *Holttum; Ridley.* The Peninsula, *Holttum 9494, Ridley 8664, 12540, 13473, Goodenough 8960, Henderson 22546, Md. Nur 11929, Hullett, Dr. King's collector 4815.* Atypical in having a more slender and lax frond are *Ridley 14200* from Perak, and *Eryl Smith 1804,* from Siam. *King 340,* from Papua, looks like *T. Christii,* but is sterile.

The reduction of *T. recedens* is on the authority of Christensen, in Gardens Bulletin 4 (1929) 377, and in notes on my specimens; I do not doubt its correctness, but have not seen the type collection.

41. TRICHOMANES VENULOSUM (Rosenstock) Copeland comb. nov. Plate 22, figs. 1 and 2.

T. bipunctatum Poiret var. *venulosa* ROSENSTOCK, Hedwigia 56 (1915) 350.

Varietas venulis spuriis creberrimis, saepe reticulatim confluentibus, badiis, inde luce transmissa valde conspicuis a typo diversa.

Nova Guinea: in monte Sattleberg dicto. IV. 1914 leg. G. Bamler no. 117.—Rosenstock, loc. cit.

Distributed by Rosenstock as *Fil. novoguineenses 211.*

I have the same plant from the same mountain, collected by Zahn in 1905. Other specimens of the same form are *King 445,* from Ambasi, and *Werner 60,* from Damun. Before noticing its identity with Rosenstock's variety, I recognized *Schlechter 16370* as specifically distinct from *T. bipunctatum,* and had it illustrated. It is the same species, in a more amply developed form. *Schlechter 17304* is a dwarf form of this species, with fertile fronds 2 to 3 cm long; *Werner 18* is intermediate between this dwarf and the typical plant. *King 464,* from the Hydrographers' Range, is another small plant, the material inadequate for confident identification.

Stipes 2 to 3.5 cm long; well-developed fronds 6 cm long, 3.5 cm broad; segments about 0.6 mm wide; false veins notably abundant, irregular, not remarkable in color in most specimens; lips of the involucre triangular, acute.

Most nearly related to *T. brevipes*, from which it is distinguished by longer stipes and more copious false venulation. Judging by far less numerous specimens, it averages larger, and is less variable.

This seems to be the common representative of the group in New Guinea. From any other land, the only specimen in my hands suggesting it is *Balansa 69*, from New Caledonia, intermediate between it and *T. bipunctatum*.

42. TRICHOMANES NYMANI Christ. Plate 19, fig. 4.

Trichomanes Nymani CHRIST in Schumann and Lauterbach, Flora . . . Südsee Nachtr. (1905) 36.

In arborum cortice caespitosum.

Rhizomate ramuloso repente sublignoso fragili tenui nec filiformi parce brunneo-hirsuto, frondibus caespitoso-approximatis erectis 1 ad 1½ cm longis ½ cm latis ovatis basi subcuneatis simpliciter pinnatifidis subsessilibus, rachi anguste alata. Pinnis 3 aut 4 utroque racheos latere, linearibus 2 ad 3 mm longis ⅔ mm latis acutis fere mucronulatis, pinnis supremis abbreviatis rarius productis et subflabellatim dispositis. Margine pinnarum linea incrassata nigra cincto undulato hic illic denticulato. Pinnis uninerviatis. Colore dilute griseo-ochroleuco sive subvirente, textura diaphana, nervis rachique nigris.

Soris raris 1 aut 2 terminalibus in pinnarum supremarum apice, minutis ½ mm latis et longis exacte campanulatis id est orificio ampliato, usque ad os alatis, labiis non dilatatis, receptaculo brevi sed exserto.

Kaiser-Wilhelmsland; Sattelberg, an Baumstämmen auf dem Gipfel (Nyman n. 506, Jan. 1899).

Haec plantula sistit formam typi T. pyxidiferi quam maxime reductam, ob pinnas simplices et dimensiones pusillas. Pinnis acutis subdenticulatis inter gregem peculiare. . . .

T. Kurzii Bedd. . . . pinnis partitis gaudet. . . .; T. Lauterbachii. . . . magis dissectum; . . .—Christ, loc. cit.

Represented in the University of California herbarium by *Schlechter 16616*, received as *T. Nymani* from Prince Bonaparte, apparently correctly named; but I detect no sign of denticulation. The fronds are spaced about 5 mm apart on a rhizome slender enough to be filiform, but crooked. The larger fronds, about 16 mm long, have a narrowly winged rachis, the few primary segments simple or deeply cleft, rarely trifid, the ultimate segments about 0.6 mm wide, and I believe, obtuse when mature. The submarginal false vein is exactly as in *T. intramarginale;* that is, separated from the margin by at most the full width

of one row of marginal cells. The involucre is bilabiate, with short, subacute lips. There is no structural evidence by which to associate this with any particular larger plant.

Known from Papua only.

43. **TRICHOMANES PERVENULOSUM v. A. van Rosenburgh.** Plates 19 and 22, fig. 3.

Trichomanes pervenulosum V. A. VAN ROSENBURGH, Philip. Journ. Sci. 11 (1916) Bot. 103, pl. 5, fig. 2.

Gonocormus.—Rhizoma repens, filiforme, copiose ramosum, probabiliter caespitosum, ferrugineo-tomentosum, demum saepe glabrum. Stipites sparsi, filiformes, 0.5 ad 5 mm longi. Frondes tenuissimae, glabrae, simplices vel saepius 2-3-fidae, basi cuneatae ad anguste longe decurrentes, segmentis primariis erectis, erecto-patentibus vel patentibus, simplicibus vel furcatis vel raro irregulariter furcato-flabellatis; frondes simplices lineares, 5 ad 15 mm longae, 1.5 ad 2 mm latae, costatae, integerrimae, apice rotundatae et interdum emarginatae; frondes divisae 5 ad 20 mm longae, 3 ad 20 mm latae, segmentis ultimis brevissimis vel usque ad 15 mm longis, parte superiore frondium simplicium similibus; venae desunt; venulae spuriae adsunt, copiosae, breves, rectae vel leviter curvatae flexuosaeque, erecto-patentes vel costae marginive parallelae. Sori 1 vel plures, ad frondem simplicem vel ad segmenta frondium divisarum solitarii terminalesque; indusium infundibuliforme, immersum, limbo dilatato, patenti, vix 2-valvi; receptaculum non vel breviter exsertum.

AMBOINA, Hitoe lama, *Rel. Robins. 1947,* November 6, 1913, on limestone rocks, altitude about 100 meters.

This species resembles in aspect *Trichomanes Aswijkii* Rac., which, however, is larger and without spurious venules.—V. A. van Rosenburgh, loc. cit.

Known by the type collection only. Of all the dwarf species described in the group, this is the least susceptible of identification with any known larger species; the affinity is to *T. venulosum.*

THE SPECIES OF THE INDO-SINO-JAPANESE REGION

The word species is singular or plural. I am satisfied that the *Taschneria* population of this area is a phyletic entity, but am undecided as to whether it is best regarded as comprising one, or a few, or very many species. Even where I have indicated reduction, the action is consciously tentative. The first species described happened to be two dwarfs, *T. intramarginale* and *T. latemarginale.* Next in order are six species described as *Didymoglossum* by van den Bosch. As the status of all of these has been regarded as dubious, I will present in full the description of the second one only; it is recognized as a variety by Baker and by Beddome; and give abstracts of the others.

44. TRICHOMANES INTRAMARGINALE Hooker and Greville. Plate 23, figs. 1 to 3.

Trichomanes intramarginale HOOKER and GREVILLE, Ic. Fil. (1831) pl. 211; BEDDOME, Ferns of Southern India pl. 208.

Pumilum, frondibus erectis subbipinnatifidis, laciniis paucis lato-linearibus erecto-patentibus subundulatis opacis costatis nervo tenui paulo intra marginem sito apicibus retusis, involucris in apicibus laciniarum terminalium cylindraceo-campanulatis, ore patente brevissime bilabiato.

HAB. Insula Zeylonae. Communicavit *Prof. Lindley*.

* * * * * * *

Stipites perbrevibus, vix semiunciam longi, subtomentosi, superne alati. *Frons* unciam longa . . . ; laciniae paucae. . . . *Involucra* . . . omnino immersa, ore paululum dilatato. . . .—Hooker and Greville, loc. cit.

I illustrate this species by a Gray Herbarium specimen, *Thwaites Ceylon Plants 3361.* Hardly identical, although in conformity with the description, is *Holttum 18312,* from Pulau Penang. Beddome cites two localities in peninsular India.

It is 2 to 4 cm tall, 10 to 15 mm wide, sparingly bipinnatifid in the lower part. It differs from *T. bipunctatum,* structurally, in that the false vein is closer to the margin, separated therefrom by at most one full row of marginal cells; and in the fructification, in that the involucre is so broadly winged as best to be described as sunk in the apex of the segment, quite to the point of separation of the lips or lobes, in a manner familiar in *Microtrichomanes* and *Hemiphlebium.* The tube is obconic, which is a characteristic of the group in India, and the lips are broadly rounded.

If any of the more amply developed supposed species be identified with this, the name will still be *T. intramarginale.* Judging by the descriptions, *Didymoglossum Griffithii* seems likely to be such a plant.

45. TRICHOMANES LATEMARGINALE Eaton. Plate 24.

T. latemarginale EATON, Proc. Am. Acad. 4 (1859) 111.

T. nanum VAN DEN BOSCH, Ned. Kruid. Arch. 5[2] (1863) 206, non Hooker.

T. Kurzii BEDDOME, Ferns Brit. India (1868) pl. 286.

T. viridans METTENIUS, Linnaea 35 (1868) 389.

T. formosanum YABE, Bot. Mag. Tokyo 19 (1905) 31, figs. 1–4.

T. palmifolium HAYATA, Ic. Formos. 4 (1914) 138, fig. 78.

Pusillum; caudice repente filiformi tomentoso; frondibus subsessilibus 3–6 lineis longis pellucidis glabris nunc palmato 3–6-partitis nunc pinnatifidis, laciniis lineari-oblongis integerrimis obtusis nervilla intra duplicem seriem cellularum marginalium cinctis; involucro omnino immerso infundibuliformi breviter bilabiato; receptaculo longe exserto; areolatione hexagonali conspicua fragmentis venularum conspersa.

Creeping on rocks in mountain ravines, near Hong Kong, China.—Eaton, loc. cit.

Collected by Charles Wright. The type collection, in the Gray Herbarium and United States National Herbarium, is composed in considerable part of digitate fronds, but the fertile fronds are pinnate in plan, even if with as few as four or five simple pinnæ; the largest are 16 mm long and 11 mm wide, with some of the primary segments subpinnatifid. I have three later collections, from the Hong Kong herbarium, all with subbipinnatifid fronds, about 2 cm long and 1 cm wide. Little as they are, they vary widely; and as I have already shown, unimportant meric variation in so small and simple a plant may involve a conspicuous modification in the terms which describe it. Besides varying from digitate to bipinnatifid, and from lanceolate to round, without any really important difference at all, they vary internally. The submarginal false vein may be little or much interrupted, and accessory striæ may be few or none, all on fronds of the same (type) collection. More remarkable, this submarginal false veinlet may, with or without interruptions, extend around the lip, or it may be entirely absent there—something I have seen in no other member of this group. The development of the mouth of the involucre is also variable. Most often, it has two broad lobes, rather than two lips, the distinction being that the mouth is dilated where they meet; these lobes may be prominent or inconspicuous.

I reduce *T. nanum* van den Bosch to this species on the evidence of *Ridley 15700,* from Kedah; it conforms exactly to van den Bosch's description, but could be duplicated by a selection of fronds from the type collection of *T. latemarginale;* and the geographic origin does not demand the assumption of distinct ancestry. *Trichomanes nanum* was described from Assam. *Trichomanes Kurzii,* described from the Andamans, is reduced on the strength of Beddome's own reduction, Ferns of British India correction sheet, of his species. It was originally described as having no lips, but in Ferns of British India and Ceylon, page 40, Beddome states that the mouth is dilated. *Trichomanes viridans,* described from Moulmein as 1 inch long, was distinguished from *T. nanum* by having the sori terminal on the fronds or the upper segments; but Beddome so depicted *T. Kurzii,* and it is the commonest position in *T. latemarginale.* Beddome's description and drawing, as *T. pusillum,* Ferns Brit. India pl. 302, would make me doubt the propriety of this reduction, showing numerous oblique striæ but no trace of a

submarginal vein; but Mettenius said "*nervi spurii striaeformes interrupti margini subparalleli.*" I have likewise not seen authentic *T. formosanum,* but its description and figures might as well have been based on the type collection of *T. latemarginale.* By comparing it only with *T. vitiense,* in a different group, its author made it appear very distinct.

I suggest this identification of *T. palmifolium* with less confidence. It is a dwarf with very incompletely dissected fronds, short, acute segments or teeth, short and oblique false veins, and semicircular lips of the involucre. Except as to the last feature, its description is perfectly matched by Hooker specimens from Sikkim, and by Hooker and Thomson specimens from Khasia, all in the Gray Herbarium, and all with very acute lips. I am not reconciled to the reduction to *T. latemarginale* of plants with distinctively oblique, short false veins—*T. nanum* van den Bosch, *T. viridens,* and *T. palmifolium;* but if *T. nanum* is *T. Kurzii,* the other reductions follow naturally.

Trichomanes acuto-obtusum Hayata, Ic. Pl. Formos. 4 (1914) 135, from Bonin, is "near *T. Kurzii,* but separable from it by the short obtuse valves of the involucres," Hayata supposing *T. Kurzii* to have a truncate involucre. So far, it might obviously be *T. latemarginale,* and the false venulation is depicted as intermediate between oblique and parallel to the margin, partly one and partly the other. But the lip of the involucre is described and drawn as "eroso-denticulate." I have a specimen from Kwangtung, *Matthew 24,* on which a majority of the involucres are of this kind, but a few have evenly rounded lips. If there are distinct species in this group and region, this is one, having an inconspicuous longitudinal false veinlet between costa and margin. On the strength, however, of this evidence of the instability of the erose lip, I believe that *T. acuto-obtusum* should be reduced to *T. latemarginale.*

46. TRICHOMANES MEGISTOSTOMUM Copeland sp. nov. Plate 23, figs. 4 to 6.

Taschneria parva, T. Makinoi C. Chr., et T. viridanti Mett. simile, involucro statu naturae e basi attenuata sensim valde explanato labiis latis brevibus undulatis sicco praestantissime bilabiato ore quam tubo usque triplo latiore; rhizomate filiforme intricato; stipitibus 3 ad 5 mm longis laminam prope decurrenti-alatis; lamina 12 ad 15 mm longa, 8 ad 14 mm lata, sterile saepe adspectu digitata, fertile aut monopodiale aut irregulariter pinnatifida, plus minus more flabelli (sicca) contracta, segmentis 5 ad 8 mm latis, sicco adspectu acutis sed vero apice rotundatis; venulis spuriis sparsis plerisque brevibus vermifor-

mibus obliquis, rarius elongatis sinuosis longitudinalibus in ala solitariis; involucro in segmento subapicale frondis terminale, anguste alata, 1.6 mm longo, ore 1.2 mm lato, venulis spuriis (an semper?) carente.

Siam, *Md. Haniff* and *Md. Nur 3981*. Type in Herb. Singapore.

Obviously related to *T. nanum* van den Bosch, which, as *T. Kurzii* Beddome, I construe as a form of *T. latemarginale*. It may occasion surprise that, at the same time that I propose to reduce a considerable number of species in this group, I describe a new one. I construe as one species all of the forms which I believe to be within an unterrupted range of variability, but regard as distinct a form which seems to be without this range. The fact that its affinity is clear is no objection to its recognition as a species; in fact the commonest cause of difficulty in placing or recognizing species is that they were described without such knowledge.

The change in shape of the involucre, as it dries out, or conversely is soaked and restored in form, is accomplished by drawing together the sides (where the wings are attached) of the involucre, as it becomes dry, making the tube, in extreme cases, narrowly linear, in the plane in which it is commonly seen. In pressing a specimen, the involucre is commonly flattened in the plane at a right angle to the plane of compression in this case. Some contraction of the kind described here can be detected in other species of this group, and may be responsible for discrepancies of description; but I have never observed it in any comparable degree in any other species. It is illustrated in a measure by Plate 23, figs. 5 and 6, but these drawings were made from the same sorus in this sequence (wet, first) and the involucre was incompletely dry when the second was made. In the herbarium, the tube is commonly contracted to one-third the width of the mouth.

47. DIDYMOGLOSSUM LATEALATUM van den Bosch. Plates 25 and 26.

Didymoglossum latealatum VAN DEN BOSCH, Ned. Kruid. Arch. 5 [3] (1863) 138.

Fronde plus minusve late lanceolata bipinnatifida, laciniis primariis erectis vel patulo-erectis subcontiguis (infimis divergentibus remotiusculis) secundariis patulis apice leviter recurvis remotis e basi lata apice 1–3 furcatis simplicibusve, lacinulis appressis anguste linearibus apice angustatis plicatulis margine undulatis, rhachi leviter flexuosa venisque (in axillis praesertim) latissime undulato-alatis, venulis angulo acutissimo exeuntibus longe procurrentibus, venulis spuriis plerisque elongatis 1–2 serialibus, submarginale nulla, cellulis teneris diaphanis irregulariter plus

minusve elongato-hexaëdris partim mediocribus, partim parvis, interaneis amorphis dilutis subparietalibus flavescentibus, parietibus hyalinis tenuibus, soris in laciniis primariis lateralibus secundariarum locum occupantibus exsertis, indusio inferne conico-tubuloso aequaliter angustato ima basi angustissime alato mediotenus bilabiato, labiis ampliatis rotundatis antice leviter porrectis, stipite ultra medium ala undulata angustate marginato 6–10 millim. longo. Rhizoma ultra setaceum repens parce ramosum fusco-tomentosum; frons 4–5 cent. longa, 12–16 millim. lata flaccida e viridi olivacea.

A praecedente [D. racemulosum] hanc distinguere suadent: forma frondis, latissima rhacheos ala, venulae spuriae elongatae biseriales, cellulae majores elongatae, indusium exsertum forma omnino diversa, etc.

Hab. India orientalis (Nepal), (Assam) GRIFFITH, H. HOOK.—Van den Bosch, loc. cit.

DIGEST OF VAN DEN BOSCH'S INDIAN DIDYMOGLOSSA [9]

DIDYMOGLOSSUM RACEMULOSUM, page 137.

Frond ovate or oblong-ovate, 3 to 5 cm long, 1.5 to 2 wide, stipe 1 cm long, narrowly winged, rachis narrowly undulate-winged, veins broadly winged, especially in axils; false veins few and short, none submarginal; involucre broadly winged (immersed), cut one-third of the way down into semicircular lips. Assam, *Griffith.*

DIDYMOGLOSSUM PLICATUM, page 139.

Fronds 5.5 to 7 by 3 to 4 cm; stipe 3 to 2.5 cm long, winged to the base; pinnæ and pinnules remote, segments plicate dry, undulate, acute; rachis narrowly winged; false veins short in two or three series, none submarginal; involucre winged, lips semicircular, one-third as long as the tube. More robust than others. Divisions subfastigiate, "folded like a fan." Malacca, *Griffith;* Ceylon, *Thwaites 2985;* (Sumatra?).

DIDYMOGLOSSUM GRIFFITHII, page 141.

Frond 3 to 4.5 by 1.6 to 2 cm; stipe 1 cm long, winged; rachis winged; one continuous, sinuous false vein near margin; sori immersed; involucre short, ventricose, mouth dilated, obscurely 2-lobed, lobes rounded, undulate. Mergui, *Griffith.*

DIDYMOGLOSSUM EUPHLEBIUM, page 142.

Frond 6 by 1 to 1.5 cm, rigid; stipe 2 cm long; pinnæ remote, segments narrow, acute; rachis narrowly winged; false veins many, short, in plural series, none submarginal; involucre immersed, subventricose, narrowly winged, lips shorter than tube, obtusely triangular. Assam, *Griffith.*

[9] Ned. Kruid. Arch. 5^{2} (1863) 137–144.

DIDYMOGLOSSUM INSIGNE, page 143.

Frond 2.5 to 3 by 1 to 1.5 cm, flaccid; stipe 1 cm long, narrowly winged; rachis broadly winged; segments undulate, obtuse or emarginate; false veins few, short, conspicuous, in one or two series parallel to margin, but none submarginal; involucre small, immersed, broadly conic, with broadly rounded lips rather longer than tube. Mishmee, *Griffith.*

In an appraisal of these descriptions, two contrasting facts stand out; namely, first they seem to be excellent descriptions, and to distinguish the plants clearly and sufficiently; and second, on seven to nine collections from one general area, all from one herbarium (Hooker's) where they passed as conspecific, six new species are based. In a group remarkable in other lands for specific instability, this is not sufficient material to justify the opinion that the species are really distinct. The Gray Herbarium and the United States National Herbarium have about as many specimens in this group, from the Hooker herbarium, and I expected them to match the van den Bosch descriptions, so that I might know the species properly at first hand; but they do not match, even closely, except in a single instance. Beddome had Hooker specimens, and transferred two of van den Bosch's names to *Trichomanes,* as *T. plicatum* and *T. insigne.* Only these two of the van den Bosch names appear in the Gray Herbarium, and both of these match Beddome's interpretation. How far this is from conformity with van den Bosch may be seen by comparing my figure of the Gray Herbarium specimen of *T. plicatum,* Plate 25, fig. 2, which is sufficiently the same as Beddome's plate, Ferns Brit. India, pl. 285, with van den Bosch's statement that the lips are "semicircularibus tubo 3plo brevioribus crenulatis." *Trichomanes insigne* is the one instance of approximate conformity, and the false veinlets are not conspicuous in specimens seen. With this qualification, and the further one that the fronds may be 6 cm long and 4 cm broad, with narrowly winged rachis, I can apply this name to collections by Gustav Mann, August, 1888, from Shillong Peak, Khasia Hills, *U. S. Nat. Herb. 329769,* and from Sootyngia, Jaintia Hills, March, 1890. Less closely, I can identify other specimens as *T. plicatum* and *D. latealatum,* but if these van den Bosch species are really distinct, I seem to have twice as many more, presenting still different combinations of the same unit characters, and mostly still represented by one collection each.

I can make no decision without collections enough to provide a much better judgment on the stability of the forms. There is no reason that *T. bipunctatum* should not have as many related species as *Athyrium Filix-foemina* in this area. On the other hand, there is no a priori ground for assuming that *T. brevipes* and *T. bilabiatum* present the limit of possible specific instability. *Didymoglossum latealatum* may be still more unstable; and in the final synthesis, it may be *T. latemarginale*. In the latter event, the following species will fall into the same basket. The forms or species of this group, as far as I know them from China, fall within the range of the Indian specimens, and *T. Makinoi* is certainly one of this group.

48. **TRICHOMANES MAKINOI** C. Christensen. Plate 27.

T. Makinoi C. CHRISTENSEN, Index Fil. (1906) 644.

T. acutum MAKINO ex Christ, Bull. Herb. Boiss. 4 (1896) 665, non Presl.

T. Tosae CHRIST, Bot. Mag. Tokyo 24 (1910) 240.

T. bipunctatum OGATA, Ic. Fil. Japon. pl. 45, non Poir.

Espèce des plus originales; par sa fronde voisine de *T. pusillum* Sw., par ses organes fructifères voisine de *T. filicula* Bory.

Plante cespiteuse en gazon très serré, à rhizomes rampants, filiformes. Fronde glabre, membraneuse, très tendre, diaphane, vert-clair, longue de 2½ cm., large de 1½ cm., presque sessile, flabelliforme-obovée, triangulairement tronquée vers un stipe des plus courts, pinnatifide à large aile centrale, segments à bord onduleux, crispé, bifurqués à la pointe, quelquefois incisés latéralement jusqu'à une aile large, se terminant tous assez brusquement en pointe très effilée et mucronulée. Nervures fortes, une par segment, stries intercalées (*spurious veinlets* Hook.), peu accentuées. Urcéoles à peu près de la grandeur et de la forme de *T. filicula*, rares, terminaux, à segments surmontés d'une dent, brièvement pédonculés, ovales, s'élargisssant vers la moitié en deux lobes larges arrondis, un peu crispés denticulés au bord; réceptacle quelquefois dominant l'urcéole.

Tosa [Japan] Nov. 1887, 1. Makino; nom indigène *Kokehoragake*, non encore trouvé par M. Faurie.—Christ, Bull. Herb. Boiss. 4 (1896) 665.

Of this species I have from the Hong Kong herbarium a Makino collection, which I have supposed to be the type collection, but it is dated November, 1888. It is from Nanokawa, Tosa, and is typical, as is also a collection by Watanabe in the Gray Herbarium dated February, 1890. Collected at the same time and place, the Gray Herbarium has another sheet labelled *T. Filicula*, identical with one in *United States Nat. Herb. 223990*, dated 1894, and with others from other Japanese localities, similarly named. The Watanabe specimen of *"T. Filicula"* is most interesting because, along with oblanceolate fronds 4 cm. long, responsible for the identification, it contains fronds of practi-

cally typical *T. Makinoi,* and any desired intermediate between these extremes, all on the same tangle of rhizomes. The false venulation is equally variable; most often, in elongate fronds, there are elongate, approximately longitudinal strands, in an irregular and broken series, farther from the margin than in *T. bipunctatum.* The segments vary from very acute to obtuse. The tube of the involucre is winged, broadly or narrowly. The lips vary from as broad as the tube to a half wider, from half as long as the tube to fully as long, and from rounded to triangular. In short, considering only specimens from the type locality, *T. Makinoi* varies in a degree comparable to that of *T. brevipes,* and through a range sufficient to include several of van den Bosch's species of *Didymoglossum.* Similar forms occur elsewhere in Japan, in Korea, and Formosa, and throughout China; but only the short forms with sharp tips have been recognized as *T. Makinoi. Hancock 137,* from Yunnan, is this species, with the charactertistic tips, but acute lips and almost no false veinlets. So, also, is *Taquet 3634,* from Korea, distributed as *T. capillatum.* So, too, I believe less confidently, is *Cavalerie, Ros. Fil. Chin. 42,* from Pinfa; and this identification of one of the Hooker collections from Sikkim, *United States Nat. Herb. 51139,* in the Gray Herbarium also, "J. D. H. 48," would be almost automatic if the specimen were from Japan.

Through such forms as *T. palmifolium, T. acuto-obtusum,* and *T. nanum* van den Bosch, the transition between *T. Makino,* and *T. latealatum* has only small gaps. In the other direction, the large and narrow forms of *T. Makinoi,* hitherto known by other names, effect the transition to such forms as were named by van den Bosch. The phyletic homogeneity of the group is certain.

8. HEMIPHLEBIUM

Minute plants with simple and entire or merely lobed fronds. As has been indicated in my general introduction, such extreme reduction in size as characterizes this group involves a simplification of structure, in the course of which the characteristics of an ancestral group may be lost. Evolutionary lines in which the salient change is one of simplification thus converge, almost of necessity. I am, therefore, in doubt as to the naturalness of a group characterized by minuteness and simplicity—which in effect are terms of negation. The species here included in *Hemiphlebium* have one common positive feature, the presence of false veinlets. Because of this one character, the group is construed as derived from *Taschneria.* It remains, however,

a pure assumption that these false veinlets are all homologous. Among themselves, they differ in various respects. Although they have been studied comparatively by Mettenius, Prantl, and Giesenhagen, and intensively by Geobel, the degree of their morphological identity seems to me to remain undecided.

The group, as here defined, is more than pantropic in geographical range, which casts doubt on its derivation, as a whole, from *Taschneria*, restricted to the Old World. It may be noted, too, that the name used, *Hemiphlebium*, is applied approximately as by Prantl, the group being more nearly the *Microgonium* of Presl.

Key to the species of Hemiphlebium.

False and true veinlets present; fronds not peltate.
  Without submarginal vein.
    Without marginal hairs.
      Fertile fronds narrow at base.
        Sori immersed, usually plural.
          Involucre tube elongate .... 49. *T. sublimbatum.*
          Involucre as wide as long.................. 50. *T. henzaianum.*
        Sori free .... 51. *T. beccarianum.*
      Base broad but not cordate.
        Apex not notched .... 51. *T. beccarianum.*
        Sorus in an apical notch.............................. 53. *T. cultratum.*
      Base cordate .... 52. *T. Motleyi.*
    Marginal hairs present.
      Fronds lobed or divided.. 55. *T. montanum.*
      Fronds entire or crenate.
        Veins close, 2 to 5 cells apart...................... 56. *T. exiguum.*
        Veins remote, many cells apart...................... 57. *T. Wallii.*
  Submarginal vein present.
    Fronds slender, over 2 cm tall............................. 60. *T. mindorense.*
    Fronds broader and shorter.
      Stipe about as long as the frond................. 62. *T. cuspidatum.*
      Stipe short or none.
        Tube of involucre slender.
          Hyaline border evident under lens.
                                                  58. *T. bimarginatum.*
          Hyaline border inconspicuous................. 61. *T. erosum.*
        Tube not over twice as long as wide.
          Tube cylindric .... 59. *T. craspedoneurum.*
          Tube obconic .... 38. *T. rupicolum.*
False veinlets present; fronds peltate.................................. 53. *T. omphalodes.*
False veinlets wanting.
  Lateral veins present.
    Stipe as long as width of frond.......................... 19. *T. barklianum.*
    Stipe not over half as long as frond-width........ 24. *T. liberiense.*
  Frond veinless except for costa .... 22. *T. vitiense.*
True veinlets absent, false veinlets present..................... 63. *T. parvifolium.*

49. **TRICHOMANES SUBLIMBATUM** C. Müller. Plate 28, figs. 1 and 2.

Trichomanes sublimbatum C. MÜLLER, Bot. Zeit. 12 (1854) 737.

Rhizoma repens tomentosum; frondes distantes assurgentes unciam unam longae vel elatiores, tenuiter membranaceae pellucide virentes sordidae, spathulato-oblongae cuneatae breviter stipitatae, margine statu juvenali integrae, statu senili sinuato-emarginatae planae, vix lobatae, obtusatae; nervi primarii e medio nascentes dichotomi, secundarii interpositi *ad marginem e cellularum quadratarum serie unica neque vena limbatum* oriundi evanescentes; cellulae *firmae amplae fuscae parietibus crassis fuscis instructae, quadratae non hexagonae;* indusia ad apicem frondis immersa cuneato-oblonga apice infundibuliformia labio subreflexa; receptaculum breviter exsertum.

Tr. Hookeri Kze. Bot. Zeit. 1847 p. 300.—*Tr. muscoides* Hook. Sp. Filic. I. p. 117, planta Javanica, excl. syn. ceteris et diagnosi.—*Tr. marchantioides* Zip. ms. in Zollinger. Coll. Fil. Jav. No. 865 et 1899.—*Tr. muscoides* Zoll. Coll. No. 865.—*Tr. sublimbatum* Zoll. Coll. No. 3500.

Patria. Java: Zollinger.

A praecedente (T. Hookeri Presl, Hym. p. 16) notis cursivis literis expressis certe refugit.—Müller, loc. cit.

Aptly described in its well-developed form as spathulate-oblong. Smaller specimens, to be regarded as juvenile but sometimes fruiting, are oblong, with a broad base. Well developed, it is usually more lobed than as figured by van den Bosch, Hymen. Jav. pl. 2, and in gross appearance is like *T. montanum,* from which it differs in the more numerous false veins and absence of marginal hairs. It is larger and commonly more lobed than *T. bimarginatum,* and without a submarginal vein.

Assam, *Mann.* Tonkin, *Pételot.* The Peninsula; Sumatra; Java; Borneo; Papua.

Trichomanes papuanum Brause, Engler's Jahrb. 56 (1920) 32, is described as distinguished from *T. sublimbatum* by slender, naked rhizome and pale green color. I have not seen the type collection, *Ledermann 7835;* but naked, threadlike rhizomes and coarser, densely hairy ones can be found mixed, in Papua (*Zahn*) and elsewhere. The shade of green is variable in most or all species of the group, and *T. sublimbatum* is normally distinctly lighter than some of the species—*T. Motleyi,* for example.

50. **TRICHOMANES HENZAIANUM** Parish. Plate 28, figs. 3 and 4.

Trichomanes henzaianum PARISH, ex Hooker, Second Century of Ferns (1860) pl. 1.

Caudice filiformi repente ramoso parce nigro-tomentoso, frondibus parvis remotiusculis brevi-stipitatis obovato-subflabelliformibus membranaceis subnitidis laete viridibus vix semiunciam longis marginibus magis minusve irregulariter lobatis vix pinnatifidis lobis brevibus obtusis, venis apice liberis primariis paucis subflabellato-pinnatis satis distinctis, secundariis iis

parallelis arctis deliculatis venulis transversis junctis et ita frondibus minute reticulatis, involucris in lobis frondium venas primarias terminantibus omnino intramarginalibus textura frondis infundibuliformibus, limbo dilatato integro, stipite gracili vix lineam longo.

Trichomanes Henzaianum, *Parish in litt.*

HAB. Detected by *Mr. Henzai*, and the *Rev. C. S. P. Parish*, partially clothing the trunks of trees at Moulmein, 1859.—Hooker, loc. cit.

Distinguished from *T. sublimbatum* "Above all, by the involucre, of which the limb in *T. sublimbatum* extends to the margin of the frond, while in our plant, the lobe of the frond extends much beyond the involucre."—Hooker, loc. cit.

Hooker figured the venation correctly, except that the strands are not thickened at their apices. There are a few fairly conspicuous main veins, of which more than half—those reaching the upper part of the frond—may bear sori. Between them are numerous fine strands, "false veins," two to four parenchyma cells apart, nearly all running to the marginal row of cells, some free at the lower end, some connecting with the veins. There are no transverse veins or veinlets whatever, submarginal or elsewhere; the only possible interpretation of Hooker's "venulis transversis" is that he was seeing the walls of the parenchyma cells.

Hooker was, of course, again in error in describing the involucre as though its halves were different, one only being provided by the lamina. As in all relatives, and as follows from the method of growth, the two halves are alike; each is like the lamina in general, in the details of size and structure of the parenchyma cells, and in the strands. However, the appearance described by Hooker is real, and characteristic. Both halves are "over-full." As the plant grows, this may result only in the extreme dilation of the involucre; but in the herbarium, and even after specimens are softened, the overfulness results in a pleating and folding, whereby parts of the involucre appear short, whichever side be viewed.

The authentic specimen studied is in the Gray Herbarium, collected in Tenasserim by Parish, possibly a part of the type collection, as Moulmein and Tenasserim are not sure to be distinguished. Wherein it fails to fit Hooker's diagnosis, it agrees with his figure too well to permit doubt of its identity.

The rhizome is about $\frac{1}{3}$ mm in diameter. The stipes are spaced about 1 cm apart and are up to 1 cm in length. The fronds are 1 cm, more or less, in length, usually not so wide, and are mostly attenuate at the base. Some fronds are decided-

ly lobed. Rhizoids are sparsely present as far up as the lower third of the midrib. The parenchyma walls are 2 to 3 μ in thickness, or up to 4 μ near the margin; but the outer walls of the marginal cells are thin, or invisible. The superficial cells of the strands have likewise walls only 1 μ thick. The involucre is about 1.5 mm long and wide, with acute base and broadly undulate margin. There are no protruded receptacles in the material studied. The most similar species is *T. sublimbatum,* from which this differs in the form of the involucre, broad, and with straight sides in *T. henzaianum,* but with a slender, inflated tube in *T. sublimbatum.*

51. TRICHOMANES BECCARIANUM Cesati. Plate 29.

T. beccarianum CESATI, Atti Accad. Napoli 7 pt. 8 (1876) 8, pl. 1, fig. 2.

T. cognatum CESATI, Rend. Accad. Napoli 16 (1877) 24, 28, non Presl.

T. minutissimum V. A. VAN ROSENBURGH, Philip. Journ. Sci. § C 11 (1916) 102, pl. 5, fig. 1; GOEBEL, Flora 124 (1930) 397 et seq., figs. 11–19.

Stirps praecedenti [T. Motleyi] simillima crescendi modo et frondium dispositione, differt vero pluribus notis. Color (in sicco) magis glaucescens; frondes minores ovatae, vel oblongae, vel lineari-oblongae, nec cordato- orbiculatae, minus pellucidae, venis crebrioribus strictis i. e. rectilinee divergentibus, nec extrorsum curvulis ut in *Tr. Motleyi;* sori singuli apicales (vix uno vel altero in speciminibus praesentibus) breviores, sed quoque ore dilatato patulo integro.

Ad arborum corticem arcte applicatum.

Sarawak; 1866.—Cesati, loc. cit.

In its vegetative phase, this is a smaller and more delicate plant than *T. Motleyi,* but with distinctly more development of the costa. In typically vegetative fronds of the latter species, the veins are radiate almost from the base, a costa reaching half the height of the frond being present only in the minority which are to be regarded as representing a transition to the fertile phase. In *T. beccarianum,* a costa reaching half the height is the rule, and it is common for it to be more prolonged. The base, deeply cordate in *T. Motleyi,* is rarely cordate at all in *T. beccarianum,* commonly rounded or broadly cuneate on small, practically sessile fronds, more narrowly cuneate on many of the still sterile fronds. The fertile fronds are exceedingly variable in form, but distinguished from *T. Motleyi* by the narrow base. It is usually easy to distinguish the two species sterile, but sometimes difficult (*Ridley 323,* Singapore; and *Leiberg s. n.,* Luzon); fertile, it is always easy.

CEYLON, *Wall; Ferguson; Thwaites C. P. 3972* in part, part being *T. Wallii.* THE PENINSULA AND SINGAPORE, Ridley *10241*, and some unnumbered collections. BORNEO, *Beccari*, the type collection. JAVA, *Bakh. v. d. Brink 5931; Mousset 85.* CHRISTMAS ISLAND, *Ridley 85.* PHILIPPINES: LUZON, *Williams 463; Merrill 3523.* MINDANAO, *Clemens* λ; *Merrill 8321; Williams 2262.* PALAWAN, *Merrill 9492.* AMBOYNA, *Robinson 1944 partim*, the type collection of *T. minutissimum.* PAPUA, *Schlechter 14921.* The most of these collections were distributed as *T. Motleyi;* some, from the Philippines, under an herbarium name meaning "naked."

52. **TRICHOMANES MOTLEYI** van den Bosch. Plate 30, figs. 1 to 4.

Trichomanes Motleyi VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 145.

Microgonium Motleyi VAN DEN BOSCH, Hymen. Javan. (1861) 5, pl. 1.

Fronde subsessili adnata e cordato orbiculari integra subundulata, sterili avenia, venulis spuriis tenuibus remotiusculis, e cellulis teneris mediocribus regularibus acutangulis viridulis (marginalibus validioribus magis opacis) contexta, fertili costa simplici, soris e sinu apicali profundo subexsertis cylindrico-ventricosis limbo ampliato integro undulato, receptaculo vix exserto.

Hab. Insula Borneo (pr. Laboan), MOTLEY No. 203 (comm. ill. W. J. HOOKER).

Rhizoma setaceum dense atro-fusco-tomentosum; frons vix ultra 4 millim. longa et lata . . . venulae spuriae flebellatim radiatimve e basi frondis vel e costae basi marginem versus tendentes tenues remotiusculae apice libero ante seriem cellularum marginalium desinentes. . . .

. . . Habitu *Hemiphlebium punctatum* (POIR.) simulat adeo, ut oculis nudis vix ab illo distingui possit . . . Praeterea in illo *Hemiphlebio* adest costa manifesta frondisque margo setulis fasciculatis reflexes praeditus est.—van den Bosch, Hymen. Javan. (1861) 5. [The diagnosis in Ned. Kruid. Arch. is practically identical.]

Characterized, within its group, by stout axial structures and usually deeply cordate sterile fronds, thus being intermediate between *T. cultratum*, which is without the cordate base, and *T. omphalodes*, which has become peltate by the fusion of the basal lobes. These three species are collectively distinguished by broad fronds and stout, short, or obsolete stipes. Of the three, *T. cultratum*, as represented by its one collection, seems to be peculiar in the absence of hairs except near the base, the others being more or less hairy almost to the margin of the nether surface.

The type collection, as indicated, was from Borneo, and sent to van den Bosch by the elder Hooker. The Gray Herbarium contains a sheet of absolutely typical specimens bearing the notation "Borneo (ded. Hooker)," which can be regarded con-

fidently as a part of the type collection. It includes possibly two hundred fronds, almost all sterile. The mature ones are mostly 5 to 7 mm wide and a millimeter less in length. From the point of attachment to the apex is 4 mm or less; a costa may extend half of this distance or may be obsolete. The venation is in the latter case wholly flabellate; otherwise it is largely so. The marginal cells are slightly differentiated; their differentiation marking the cessation of growth of the frond. Short black hairs are then found on all veins, from the base almost to the margin.

The fertile fronds are, of course, costate. The base is truncate or very broadly cuneate, rarely shallowly cordate. The apex is cleft, commonly one-third of the depth of the frond, sometimes even more deeply. The sorus is sessile or short-stipitate (by the extension of the costa above the base of the cleft); it is about 2 mm long, with flaring but not really lobed lip.

I have perfectly typical material from Bukit Panday (as well as the label can be read) ex Herb. Singapore, 1905. With this exception, the many specimens labelled *T. Motleyi* are all smaller ferns with the base rounded, usually not at all cordate sterile fronds, and narrowly cuneate fertile fronds with longer and mostly slender stipes. If all one species, these should be called *T. beccarianum;* this applies to all specimens seen from the Philippines, Ceylon, Java, and New Guinea. *Trichomanes pannosum* Cesati, Rend. Accad. Napoli 16 (1877) 24, 28, seems by description to be *T. Motleyi.* As to the occurrence of *T. Motleyi* in Queensland, see Domin, Bibl. Bot. 20 (1914) 9.

53. TRICHOMANES CULTRATUM Baker. Plate 30, figs. 5 to 7.

Trichomanes cultratum BAKER, Journ. Bot. 17 (1879) 293.

Rhizome filiform, wide-creeping. Stipe very short. Lamina suborbicular, entire, ⅓ in. diam., glabrous, firm in texture for the tribe, the margin entire and naked, the base cuneate or rounded, the midrib distinct above the middle in the sterile fronds, in the deeply emarginate fertile fronds reaching to the deep apical sinus, and bearing a single free funnel-shaped involucre, with a large spreading two-lobed mouth. Receptacle not protruded. Veins radiating flabellately from the sides and tip of the midrib. Sori never more than one to a frond. On trunks of trees in shady woods of Bua, Vanua Levu, *Horne,* 1078! Closely allied to *V. Motleyi* V.D.B.—Baker, loc. cit.

The rhizome is filiform in fact, but stout in proportion to the size of the fronds, and everywhere densely covered with black hairs, as are also the short stipes. In the relative stoutness and hairiness of these axial structures this species is like *T. omphalodes* and *T. Motleyi,* in contrast with the slenderness of

these structures in *T. beccarianum* and *T. vitiense*. The mature fronds are mostly about 4 mm long and 3 mm wide, with the apex broadly rounded on sterile, cleft on fertile fronds. The base is usually obtuse or rounded but sometimes short-cuneate, especially on fertile fronds. The costa is rather stout, extending more than half the length of adult sterile fronds. The veins are few, those originating from the costa usually extending to the marginal cells. False veins are likewise few and commonly fall short of the margin. The sori are large in proportion to the fronds, about 2 mm long, and more than 1 mm wide at the top, flaring, but not really bilabiate.

The species has been known from the type collection only, but I am unable to distinguish by description *Trichomanes Sayeri* F. v. M. and Baker, Ann. Bot. 5 (1891) 195.

Rhizome wide-creeping. Stipe very short. Frond orbicular, or obovate-cuneate, $\frac{1}{8}$–$\frac{1}{6}$ in. long, deeply emarginate, with rounded apical lobes. Midrib distinct from base to apex; veins flabellate. Indusium solitary, terminal, stipitate; lips orbicular. Trinity Bay, Queensland, *Sayer*.—Baker, loc. cit.

The first publication of this name was in v. Muller's Second Census 230; the reference there to a still earlier publication is in error.

Domin, Bibl. Bot. 20 (1914) 9, says it is wide-spread in the Bellenden-Ker Mountains, epiphytic on tree trunks and rarely on moist rocks, altitude 100 to 200 meters.

54. TRICHOMANES OMPHALODES (Vieillard) C. Christensen. Plate 31, figs. 1 to 6.

Trichomanes omphalodes (Vieillard) C. CHRISTENSEN, Index (1906) 646.

Microgonium omphalodes VIEILLARD ap. Fournier in Ann. Sci. Nat. V 18 (1873) 255.

Trichomanes peltatum BAKER, Journ. Linn. Soc. 9 (1866) 336, pl. 8, C, not *T. peltatum* Poiret.

Frondibus imbricatis tenuiter membranaceis sessilibus peltatis suborbicularibus, venis et venulis spuriis flabellatim dispositis, involucris paucis inclusis, ore late dilatato.

Rhizome wiry, slender, wide-creeping, tomentose. Fronds quite sessile, attached to the rhizome near the centre or towards the base, suborbicular in general outline, half an inch to an inch and a half across each way, quite adpressed to the surface on which they grow . . . involucres cylindrical, coriaceous in texture, more or less exserted, with a very much dilated slightly two-lipped mouth.

SAMOA, July 1864, *Powell, 125*.—Baker, loc. cit.

I have seen this fern from Samoa, Tahiti, Rarotonga, Fiji, New Caledonia, New Guinea, Amboina (the type collection

of *T. minutissimum*), and Java (*Bakh. v. d. Brink 3340*). It has been reported from continental Asia, Formosa (Matsumura and Hayata, Enumeration 567), and Liu Kiu; but I mistrust these reports. It is reliably reported in Queensland.

It is at once a well-characterized and a variable species. Typically it is peltate, practically sessile, fixed near the center, and approximately orbicular, either nearly flat or with the center depressed, and overfull enough to be wavy of surface and with deflexed or moderately ruffled margin. The point of attachment is sometimes eccentric, rarely almost marginal. Growth, of course, begins at this point, and the form at any time depends on the uniformity of growth around the periphery. Growth is long-continued; even fruiting fronds sometimes have parts of the margin still active. The margin finally ceases growth, without becoming differentiated. The largest fronds seen, 25 mm in diameter, are from New Caledonia and New Guinea.

Main veins spring from the point of attachment. A few of these produce sori; the majority end just inside the margin. Between them are numerous strands or false veins, most of which are free at the inner end, and do not quite reach the margin. The parenchyma cells are in fairly regular radial rows, with walls 3 to 4 μ in thickness. The superficial cells of the strands are very thin-walled.

The tube of the involucre is "typically" immersed, 2 to 3 mm long and about 1 mm wide. Whether, when it is mostly or wholly free, this is the result of growth or of splitting, I do not know. The limb is 2 mm wide, often flat and orbicular, sometimes two-lipped in appearance, rarely really somewhat bilabiate. Very few of the sori examined retained any protruded receptacles, and these were short. The annulus is of about 23 thickened cells and about 4 thinner-walled ones forming an imperfect stomium.

55. TRICHOMANES MONTANUM Hooker. Plate 31, figs. 7 and 8.

T. montanum HOOKER, Ic. Plant. (1837) pl. 187.

T. quercifolium HOOKER and GREVILLE, Ic. Fil. pl. 115, non Desv.

T. Robinsonii BAKER, Journ. Linn. Soc. Bot. 9 (1867) 339, pl. 8, fig. B.

Frondibus oblongis basi attenuatis subsessilibus pinnatifidis, laciniis obliquis oblongis obtusis subsinuosis fructiferis terminalibus cuneatis, involucro exserto urceolato apice bialato, columna longe exserta.

Hab. . . . Esmeraldas, Colombia. . . .

I am not aware that this can be confounded with any known species of Trichomanes. . . .—Hooker, Ic. Plant., loc. cit.

Trichomanes quercifolium Hooker and Greville was described eight years earlier, from the same collection. *Trichomanes Robinsonii* was described from Natal specimens, but later reduced by its author to *T. pusillum,* along with *T. quercifolium.* As to *T. pusillum,* I am not sure, but believe that it has an immersed sorus. The Natal plant differs from the run of South American specimens in being smaller, and with less dilation of the lips of the involucre; however, the American specimens are not constant in either respect, and the identification is reasonable.

The fronds are 1.5 to 2 cm long, short-stipitate, dilated upward, and there more or less deeply and irregularly pinnately lobed. The margin is beset with clustered dark hairs, likely to be appressed. False veinlets are present, but not very numerous, nor conspicuous. The involucre is narrowly winged, and strongly bilabiate.

56. **TRICHOMANES EXIGUUM** (Beddome) Baker. Plate 32, figs. 1 and 2.

Trichomanes exiguum (Beddome) BAKER, Syn. Fil. (1874) 464.
Hymenophyllum exiguum BEDDOME, Ferns of Brit. India (1868) pl. 275.

Rhizome creeping pilose, stipes about 1–2 lines long, pilose at the base, fronds ¼ to ½ an inch long by 1–2 lines broad linear-oblong entire or slightly repand at the margin, veins pinnate from a central costa simple or forked, spurious venules few but nearly as prominent as the veins not reaching the costa and often not touching the margin, never anastomosing; involucre solitary terminal the base sunk in the frond, valves entire large and spreading receptacle exserted or included.

Hab. On trees in dense forests (3–4,000 feet elevation) Wynaad and Coorg.

Some of the fronds are furnished round the margin with minute brown hair-like appendages, . . .—Beddome, loc. cit.

I know this species only from Ceylon specimens: ex Herb. William Ferguson, in the United States National Herbarium and the Gray Herbarium, the latter fine and ample; and from another sheet in the Gray Herbarium, *Beckett 2364.* The last was (presumably, but without number) cited by Beddome in the notes following his diagnosis, and is thus authentic.

The rhizome is hardly 0.2 mm in diameter, and bears very short hairs. The fronds may be densely imbricate because the rhizomes interlace, but on the single rhizome they are spaced,

either separate or slightly imbricate. The short stipe is still more slender than the rhizome. The sterile fronds are 3 to 5 mm long, broadly ovate, subcordate-rounded at the base, rounded at the apex, obscurely crenulate at least in the upper part. The black marginal hairs are the most conspicuous characteristic. These are single or paired, or sometimes clustered, and easily broken off. The costa is evident well toward the apex of the frond; the lower parts of it and of the lower veins bear hairs on the nether surface. The fertile fronds are more slender than the sterile, and are broader above, instead of at, the base. The tube of the involucre was described as partly immersed. In the limited material seen, I find it wholly immersed; or half immersed, with or without a broad wing on the upper part; or only one-quarter immersed—all on fronds shown to be uninjured by the presence of marginal hairs near the sorus. The involucre is 1.5 mm long, with a flaring mouth 1 mm wide, somewhat plicate in the herbarium and apparently bilabiate—whether or not really so, I am in doubt. The receptacle is long enough to be seen, but is hardly excurrent.

Trichomanes Giesenhagenii C. Christensen, Index 641 [*T. microphyllum* Giesenhagen, Flora (1890) 439, pl. 14, fig. 2], known to me only by description and figure, must be very like *T. exiguum*, which was evidently unknown to Giesenhagen. It is described as larger, about 7 mm long, and with many false veinlets. It is to be noted that he regarded any vein without vascular tissue as "false," while I use the term only for those strands which are not connected with the costa, whatever their composition.

Habitat, Joanna Island, in the Comores. Found mixed with *T. cuspidatum.*

57. TRICHOMANES WALLII Thwaites. Plate 32, figs. 3 to 5.

Trichomanes Wallii THWAITES ex Trimen, Journ. Bot. 23 (1885) 274.

Fronds simple, ¼ to nearly ⅜ in. long, mostly broad-ovate, with a cordate base and very obtuse apex; margin minutely and distantly denticulate; venation subradiate, the midrib being distinct, but lost before reaching the apex of the frond; no spurious venules; involucres solitary, terminal, not placed in a sinus, and not or very slightly exserted beyond the margin of the frond; border of mouth flat, spreading, entire.

Hab. Stones and tree-trunks in the stream running through the Labugama Elephant Kraal, March, 1870, collected with masses of *T. muscoides* by Mr. W. Ferguson (C. P. 3989 in Herb. Perad.). Rhizome very slender; fronds not crowded, subsessile.

Very near *T. Motleyi* V. de B., and perhaps not more than a variety of it, but distinguishable by the sunken not exserted involucres. The shape of the fronds varies; the ones bearing fruit are less cordate, or even tapering at the base.

The name *T. Wallii* Thw. has been published in Mr. W. Ferguson's pamphlet, 'Ceylon Ferns' (Columbo, 1880), preface, and in Mr. G. Wall's 'Check List.'—Trimen, loc. cit.

Baker, Ann. Bot. 5 (1891) 194, published an independent diagnosis, in which may be noted: "Frond ovate or orbicular, ciliated, entire, $\frac{1}{8}$–$\frac{1}{6}$ in. long. . . . Indusium funnel-shaped, immersed, with a broad entire collar-like border."

Of this, I have in hand specimens ex Herb. William Ferguson from the United States National Herbarium and the Gray Herbarium; although without "C. P." numbers, these may represent the type collection. The Gray Herbarium specimen of *C. P. 3972*, "Trichomanes Henzaiense Bedd.," consists of two strips of bark well covered with minute *Trichomanes*. One is *T. beccarianum*, the other *T. Wallii*. As *T. henzaiense* (Hook.) was only a misprint of *T. henzaianum*, it should be ignored as a name; it was figured from a Burma specimen.

Trichomanes Wallii was apparently intended to be distinguished from *T. exiguum* by the more completely immersed tube of the involucre, and by the absence of false veinlets. As the degree of immersion is altogether inconstant in *T. exiguum*, this distinction does not hold; also, it is inconstant in *T. Wallii*. Neither are false veinlets wanting in *T. Wallii*—they are only unusual; on some fronds I detect a single veinlet failing to run down to the costa.

Judging by the material seen, *T. Wallii* is much more lax in venation than is *T. exiguum*, the veins or false veinlets being separated by only two to four or five rows of laminar cells in the latter, by ten or more rows in the former. I do not know that this or any other distinction between them is really constant.

Trichomanes paradoxum Domin, Bibl. Bot. 20 (1914) 10, pl. 2, fig. 4, is known to me only by its description and picture; it seems to differ from *T. Wallii* in having a more hairy margin, and repeatedly forked veins; there is no mention of false veinlets, but Domin could have overlooked them as easily as Baker did. Whether or not the two species are identical, they are very similar. I have suspected the presence of *T. Wallii* in Borneo, having a specimen without label, which seems likely to have been Bornean.

58. TRICHOMANES BIMARGINATUM van den Bosch. Plate 33, figs. 1 to 4.

Trichomanes bimarginatum VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 143; Journ. Bot. Néerl. 1 (1861) 346; DOMIN, Bibl. Bot. 20 (1914) 11, pl. 3, fig. 2.

Microgonium bimarginatum VAN DEN BOSCH, Hymen. Javan. (1861) 7.

T. yandinense BAILEY, Syn. Queensland Fl. (1883) 686.

T. bimarginatum; T. muscoides Brack. p. 249 (*non alior.*) in WILKES expl. exped. XVI p. 249. Fronde breviter stipitata e basi cuneata oblonga vel obovato-oblonga, fructifera apice angustata, margine integro repando undulato, costa flabellatim in venas simplices furcatasve abeunte, interpositis venulis spuriis in venulam submarginalem confluentibus, cellulis diaphanis magnis regularibus elongato-hexaëdris pachydermis amoene viridibus globulosis, marginalibus dissimilibus majoribus abbreviatis 3–4'edris, soris mediocribus immersis, indusio cylindrico longe angustato, sursum in limbum amplum undulatum subito dilatato, stipite complanato dense fusco-tomentoso 4 millim. longo. Frons vix ultra 1½–2 centim. longa, 6–8 millim. lata.

Hab. Ins. Ceylon: THWAITES no. 2986; Ins. Fidchi: WILKES.—Van den Bosch, op. cit. 143.

From the "preliminary publication" in Hymenophyllaceae Javanicae, I would regard the Ceylon specimen as the type; it and the Fiji plant are perfectly identical. The fronds are elliptic, oblong or obovate, with either rounded or cuneate base. The false veins are numerous and conspicuous, as are also the submarginal vein in which the others terminate and the single row of hyaline marginal cells. The fronds may be entire, in which case the tube of the involucre is immersed; or cleft or irregularly but not deeply lobed, in which case the sori occupy lobes, and the appearance is rather that of being broadly winged than of being immersed involucres.

Ceylon, the Peninsula, Papua, New Caledonia, Fiji, Samoa, Queensland. Probably common but too small to be conspicuous. This wide-spread species may be regarded as the type and probable parent of a subgroup, of which *T. cuspidatum, T. erosum, T. mindorense,* and *T. craspedoneurum* are local or outlying representatives.

59. TRICHOMANES CRASPEDONEURUM Copeland. Plate 33, figs. 5 to 7.

Trichomanes craspedoneurum COPELAND, Philip. Journ. Sci. 7 (1912) Bot. 53.

Rhizomate filiforme repente; stipitibus brevibus vel subnullis, minute pilosis; fronde 1 ad 1.5 cm longa, oblanceolata, integra vel saepius paucilobata, deorsum angustata et pilifera, sursum glabra; venatione pinnata, venis spuriis obliquis sat conspicuis, cum vena submarginale anastomosantibus; soro solitario apicale, tubo cylindrico omnino immerso, limbo dilatato, cum margine anastomosante et deinde bilabiato.

LUZON, Province of Tayabas, Infanta, alt. 100 m, *J. B. Leiberg*, sheet No. 593183, U. S. Nat. Herb.

Distinguished from *T. sublimbatum* K. Müll, and *T. henzaianum* Hooker by the evident submarginal vein. Near *T. Petersii* A. Gray of Alabama.—Copeland, loc. cit.

Nearly related to *T. bimarginatum,* but with distinctly fewer false veins and broader involucre.

60. TRICHOMANES MINDORENSE Christ. Plate 34, figs. 1 and 2.

Trichomanes mindorense CHRIST, Philip. Journ. Sci. **3** (1908) Bot. 270.

Vicinum T. neilgherrensi Bedd., a quo discrepat venulis spuriis nullis, fronde lateraliter lobata, textura crassiuscula, opaca.

Nanum caespitosum, rhizomate ramoso intricato tenui minuto squamuloso brunneo, foliis confertis numerosis dense caespiticiis, sessilibus, 1.5 cm longis, 2 ad 3 mm latis, aut simplicibus anguste lanceolatis versus basin longe attenuatis obtusis, aut lateraliter et in apice lobatis, lobis 1 ad 4, 1.5 mm longis, rotundato-ovatis, obtusis, costa manifesta nigra, nervis obliquis manifestis 6 ad 8 utrinque, simplicibus, ad marginem protensis, nervulis spuriis nullis, margine linea tenuissima cincto. Basi foliorum setulis brunneis vestita, planta aliter nuda. Soris in apice terminalibus omnino immersis subreniformi-dilatatis vix 1 mm latis, ore non prominente angusto, receptaculo interdum longe exserto. Colore brunneo-viridi opaco, textura adiaphana crassiuscula.

MINDORO, Binabay River, *Merrill 6066,* November, 1906.—Christ, loc. cit.

Although most of the items in the diagnosis are applicable to individual fronds, the species is a tenable one, distinguished from *T. bimarginatum* by the extreme slenderness of the fronds. The rhizome is very slender, hardly 0.2 mm in diameter, or apparently thicker because of its felt of hairs. The space between fronds is commonly 5 to 8 mm. The stipe is usually about 1 mm long, sometimes 2 to 5 mm. It is hairy, but the costa is naked except at its base.

The fronds are about 2 cm long, rarely simple, and then hardly 2 mm wide; usually they bear one to several lobes in the upper part and may there reach a width of 4 to 6 mm, over all. The base is very attenuate. The margin is sometimes entire, in which case the veins are unbranched, as described; or it may be sinuate, with the protruding wave often supplied with a forked vein; my drawing shows more of these than are usual. As to false veins—such as do not connect with the costa—Christ was in error. Very few of these are evident with a simple lens, but greater magnification always shows some very small scattered ones, as well as a break at the bottom of some of those which with the lens seem connected with the costa. The intramarginal strand is like that of *T. bimarginatum,* but the radial veins are less numerous.

The tube of the involucre is very slender, about 2 mm long, and immersed—that is, broadly winged throughout. The mouth is abruptly dilated, 1.3 to 1.5 mm wide, not at all bilabiate; it is traversed by radial strands like fine false veins. Protruding receptacles 2 mm long are common in the material studied.

The ample type collection of this species has never been exactly duplicated. *For. Bur. 19599 H. M. Curran,* Cagayan Province, Luzon, is referable to it, but deviates in the direction *T. bimarginatum.* Its fronds are 2 to 2.5 mm wide when unlobed, and there is a correlated tendency for the veins to be close, forked and free, and toward a less acute base.

61. TRICHOMANES EROSUM Willdenow. Plate 34, figs. 3 to 6.

Trichomanes erosum WILLDENOW, Sp. Pl. 5 (1810) 501.

T. frondibus stipitatis oblongis erectis cuneatis irregulariter pinnatifido-incisis, laciniis inaequalibus obtusis undulatis. W. Ausgenagter Becher-farrn.

Habitat in Oware *et* Benin Africes. ♃ (*v. s.*) *D. Flügge.*

Caudex *filiformis repens crassitie setae equinae.* Stipes *quadri- vel quinquelinearis filiformis.* Frons *longitudine stipitis vel parum longior erecta oblonga, basi cuneata, pinnatifido-incisa, laciniis inaequalibus obtusis subrepandis undulatis.* Sorus *versus apicem frondis indusio urceolato inclusus.*—Willdenow, loc. cit.

Without a specimen, but depending apparently on a figure published by Palisot de Beauvois, van den Bosch, Synopsis 15, classified this as having "venulae spuriae, secus marginem junctae." Immediately afterward, Ned. Kruid. Arch. (1863), he described on page 200 *T. crispulum,* said to be from the Antilles, very similar to *T. erosum,* with the submarginal vein, and stipe of varying length, up to 8 mm long; and on page 201 *T. aerugineum,* from Fernando Po, subsessile, with false veins ending free within the margin. Both of these were promptly reduced by the usually careful Kuhn, Filices Africanae (1868) 34, to *T. erosum,* wherein he has been followed by Hooker (teste Baker, Syn. Fil. 75—but all of them further reduced to *T. muscoides* Sw.) and Christensen.

My material does not justify a judgment. If they are indeed all one species, varying enough to include the two of van den Bosch, it should include the specimen from Liberia, the subject of Plate 34, figs. 3 to 6, which I have accordingly called *T. erosum.* In what might be expected to be specific characters, it differs from Willdenow's description only in having a short stipe.

62. TRICHOMANES CUSPIDATUM Willdenow. Plate 32, figs. 6 and 7.

Trichomanes cuspidatum WILLDENOW, Sp. Pl. 5 (1810) 499.

T. frondibus ovatis acuminatis obtusis stipitatis, basi cuneato-subtruncatis, grosse crenatis undulatis. W.

Zugespitzter Becherfarrn. W.

Habitat in insula Borboniae. ♃ (*v. s.*) *D. Flügge.*

Stipes *quadrilinearis compressus setis paleaceis parvis obsitus.* **Frons** *pollicaris vel brevior ovata vel oblonga, basi cuneata vel truncata, apice attenuata obtusa, margine profunde et obtuse crenata undulata, membranacea, nervoso-venosa, apicem versus et margine fructificans.*—Willdenow, loc. cit.

Better described, as well as pictured, as *T. Bojeri,* by Hooker and Greville, in Icones Filicum II (1831) pl. 155.

Trichomanes *Bojeri;* fronde simplici flabelliformi membranacea radiatim nervosa glabra lobata, lobis rotundatis subcrenatis soriferis, involucris omnino immersis, stipite elongato.

* * * * * * *

Stipites unciam ad sesquiunciam longi. . . .—Hooker and Greville, loc. cit.

Of this species I have seen a single collection, made by Mrs. Nicholas Pike, in Mauritius, in 1869, *U. S. Nat. Herb. 593139.* The venation is that of *T. bimarginatum,* from which the naked eye distinguishes it by its long stipe. Both rhizome and stipe are glabrescent. The fronds vary from roundish to narrowly oblong, 25 mm long by 7 mm wide. The base is as described by Willdenow, truncate, broadly cuneate, or narrowly decurrent. The venation is flabellate in broad forms, but there is a weak costa in narrow fronds. The fertile lobes vary in width. When they are narrowest, the lamina is a wing only a few cells wide along the upper half of the tube of the involucre.

Unknown except from the Mascarenes, and rarely collected there.

63. TRICHOMANES PARVIFOLIUM (Baker) comb. nov.

Hymenophyllum parvifolium BAKER, Journ. Linn. Soc. Bot. 9 (1866) 340, pl. 8, fig. E.

Trichomanes microphyllum KUHN, Linnaea 35 (1868) 389.

Frondibus lineari-oblongis indivisis vel uni- vel bifurcatis, costa centrali sola, venis lateralibus nullis, venulis spuriis liberis, involucro solitario incluso, ore late alato.

Rhizome slender, wide-creeping, tomentose. Stipes a line long or less, naked or slightly tomentose. Frond two or three lines long by a line broad, linear-oblong, undivided or once or twice cleft at the apex, sometimes slightly, sometimes nearly halfway down, with a central costa only, which runs down the centre of each lobe when the frond is divided; lateral veins none, but marked with faint irregular free spurious venules; the margin slightly undulated, glabrous; the sorus solitary, terminal; the involucre globose-triangular, narrowed into the costa, about as deep as the convex broadly rounded valves.

Moulmein, *Rev. C. Parish,* 1862.—Baker, loc. cit.

Rhizoma capillare arrhizum; folia distantia, membranacea, laete viridia; glaberrima, 1–3‴ longa, brevi petiolata, lanceolato-oblonga, indivisa,

bi- trifida; lobis brevi-oblongis s. oblongis, obtusis, apice emarginatis; costa excurrens s. more laminae divisae; nervi spurii striaeformes, obliqui, pauci nec costam nec marginem attingentes; sorus laminam terminans basi cuneata immersus; labiis triangulari-ovatis.

Moulmein. (Parish 1862. in Herb. Hook.)—Kuhn, loc. cit.

I dislike to change the name without seeing the plant, but there is no doubt that it is a *Trichomanes*. It may represent the final stage in the reduction of *T. latemarginale*.

9. THE GROUP OF TRICHOMANES RADICANS

Large ferns, with coarse, scandent or creeping rhizomes and decompound fronds, simple and uniform cell structure, the walls uniformly if at all thickened; involucre cylindrical, and not strongly bilabiate. In the Tropics and mild-temperate regions of both hemispheres. Throughout the group, the fronds tend to be dark.

This group links the large-leaved elements of the genus to the presumably more primitive element with filiform rhizomes; and the single species *T. radicans* fairly covers, in the matter of size, the range from typical *T. pyxidiferum* to the largest-leaved species.

Besides the species herein recognized or explicitly reduced to synonymy, there are two, *T. Fargesii* and *T. Miyakei*, to which I am unready to do either; their original descriptions are quoted, following the discussion of the species known to me.

Key to the species.

Frond simply pinnate .... 72. *T. auriculatum.*
Frond decompound.
  Mouth of involucre ciliate .... 71. *T. superbum.*
  Mouth not ciliate.
    With abortive fronds at base of normal fronds.
      69. *T. aphlebioides.*
    Without abortive fronds.
      Rachis winged.
        Axes of pinnules winged as narrowly as segments.
          Involucre evidently bilabiate........ 68. *T. johnstonense.*
          Not or hardly bilabiate........ 67. *T. maximum.*
        Pinnules less deeply dissected.
          Fronds deltoid, long-stalked........ 66. *T. cyrtotheca.*
          Fronds elongate.
            Frond almost black .... 65. *T. davallioides.*
            Frond green or dark green........ 64. *T. radicans.*
      Rachis wingless .... 70. *T. giganteum.*

64. TRICHOMANES RADICANS Swartz. Plate 35, figs. 1 and 2.

T. radicans Sw., Schrader's Journ. Bot. (1800) 97; Fl. Ind. Occ. 3 (1806) 1736; HOOKER, Sp. Fil. 1: 125.

T. speciosum WILLD., Sp. Plant. 5: 514.

T. anceps WALL., Cat. No. 166, nomen, non Hooker.

T. birmanicum BEDD., Ferns Brit. Ind. Suppl. 3, pl. 349.

T. japonicum FR. and SAV., Enum. Pl. Jap. 2 (1879) 207, 618.

T. orientale C. CHRISTENSEN, Index (1906) 646; OGATA, Ic. Fil. Jap. pl. 47.

T. naseanum CHRIST, Soc. Bot. Fr. Mém. 1 (1905) 11; OGATA, Ic. Fil. Jap. pl. 46.

T. liu-kiuense YABE, Bot. Mag. Tokyo 19 (1905) 35; CHRIST, Bot. Mag. Tokyo 24 (1910) 239.

T. amabile NAKAI, Bot. Mag. Tokyo 28 (1914) 65.

T. quelpaertense NAKAI, Bot. Mag. Tokyo 28 (1914) 66.

T. kalamocarpum HAYATA, Ic. Pl. Formos. 5 (1915) 260, fig. 93.

TRICHOMANES, frondibus alternatim tripinnatifidis, laciniis bifidis obtusis, urceolis exsertis; stipite rachique marginatis; surculo scandente.

Incolit arbores montium *Jamaicae.*

* * * * * * *

Frondes sparsae, *stipitibus* 1–3-pollicaribus teretibus a foliolis decurrentibus marginatis s. subulatis; pedales, ovato-lanceolatae, subtripinnatae, saturate virides, glabrae, subpellucidae. *Raches* universales partialesque marginatae . . .

Urceoli fructificationum subpedicellati, quasi exserti, prope axillas laciniarum, cylindracei, ore membranaceo patulo. . . .—Swartz, Fl. Ind. Occ. 3: 1736.

In citing synonyms, I have confined myself to the Orient, including *T. speciosum,* described from Teneriffe, because many Oriental specimens have been given this name. A fern has to be variable to be named anew so many times. In Jamaica, the type locality, the fronds are commonly 15 to 25 cm long and broadly ovate, but smaller fronds can be fertile; the stipe is usually short, but varies from one-fifteenth of the frond's length to as long as the frond, and may be broadly winged throughout, or wingless except near the top. Throughout the American (continental) Tropics, the common form or variety, once called *T. kunzeanum,* averages larger and more dissected than does any Oriental form. Going north to Alabama, while fronds may be 20 cm long, 8 cm is commoner, and the outline lanceolate-ovate; and from the extreme limit of the species, in Kentucky, our fronds are less than 5 cm long; but nobody questions that these are real *T. radicans.*

The range in size and in dissection of the Oriental forms I reduce to *T. radicans* is not as wide as that already familiar in this species in America. It is granted that the duplication of Oriental forms by American forms which cannot be maintained as distinct species, does not quite disprove the specific nature of the Oriental forms; but the fact is that the forms I have reduced are not distinguishable in the Orient, either. It is worth while to note that the authors of the most generally recognized of the species I have reduced, *T. japonicum* Fr. and Sav. (*T. orientale* C. Chr.), distinguished it from *T. radicans* by its greater size, their *T. radicans* being just such a reduced form as represents the same species at its extreme north in the United States and in France. Subsequent authors of "new species" have located them as intermediate between *T. orientale* and *T. radicans,* meaning thereby that they were larger than *T. orientale* and, as a rule, correspondingly dissected. Such species are no sooner recognized than their range is found to be very wide, because *T. radicans* is plastic locally, as well as in a wider geographic sense. If *T. orientale* were a species, its name would be *T. birmanicum.*

In its ample forms, *T. radicans* is likely to have fronds 30 cm or more long on rather short stipes, and to be shallowly tripinnatifid with the larger segments cleft. It is constantly distinguishable from *T. maximum* by the undissected middle area of its pinnules; the texture is less firm, but both are typically very dark in color; and the rhizome is beset with persistent dark bristles. The stipe and rachis are usually evidently, sometimes broadly winged; but the wing may disappear very completely after being present, and be wanting from the start on the lower part of the stipe. The involucre is tubular, variable in length, stalked, sessile, or somewhat immersed at the base, almost truncate or considerably dilated at the mouth, and commonly slightly cleft at the sides or more evidently, but still not conspicuously, bilabiate.

In consideration of its range in stature and dissection, and of its geographical range, it is reasonable to regard this species as connecting the groups and species with large fronds and the groups with filiform rhizomes, the latter being regarded as the more primitive element of the genus. It is more than possible that in the reduction of species I have not gone far enough—that forms of *T. radicans* more reduced than I have recognized as such still remain in the group of *T. pyxidiferum.*

Western Africa; northern India, China, Korea, the Japanese Islands, south to Formosa, Indo-China (*Pételot 3605, et al.*), and Siam (*Winit 936,* in Herb. Singapore). There is also one collection, *Yates 71,* from Sumatra-East Coast, which seems to be a large form of this species, with almost sessile fronds.

65. **TRICHOMANES DAVALLIOIDES** Gaudichaud. Plate 36.

T. davallioides GAUDICHAUD, in Freycinet, Voy. Bot. (1826) 378.
T. sandvicense VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 165.

T. Frondibus sparsis, lanceolatis, bipinnatis, subtripinnatis, pedalibus; pinnulis lanceolatis, pinnatifido-dissectis; laciniis oblongis, obtusis, apice bi- vel trifidis; soris oblongis, axillaribus, subpedicellatis; rhachi stipiteque marginatis; caudice scandente, villoso.
In insulis Sandwicensibus (Wahou . . .).
. . . Grimpe jusqu'au Sommets des arbres. . . .—Gaudichaud, loc. cit.

A very common fern, often collected; in hand from Kauai, Oahu, Molokai, Maui, and Hawaii. It is well described by Hillebrand, Flora of the Hawaiian Islands 636, except for his statement that it is quite uniform. He says also that the stipes are ¼ to 5 inches long, which gives a better idea of its uniformity. The rhizome is freely scandent, 1.5 to 3 mm in diameter, densely beset with short hairs, tardily glabrescent, the fronds separated by less than their own width. The fronds reach a length in excess of 40 cm. They are lanceolate, oblong or ovate, commonly broadest about the middle, but subsessile ones may be truncate at the base. The axes are narrowly winged. Well-developed, fully fruiting fronds are four times pinnatifid, with segments hardly 1 mm wide, and the axes of the pinnules winged only to the same width; less dissected forms are also common. The color is a very dark green, sometimes nearly black. The laminar cells have uniformly thin, straight or curved, not wavy walls. The sori are cylindrical, 2 to 2.5 mm long, flaring at the mouth, often appearing bilabiate in pressed specimens, but not really so.

This is very near to the West Indian *T. radicans* Sw. Since it has no other equally near relative in the whole Pacific area, it is reasonable to regard it as descended from immigrants from America. It is the only Polynesian *Trichomanes* apparently of American origin.

Trichomanes sandvicense van den Bosch was described from a Wilkes Expedition specimen with very short stipes. The Wilkes specimens in the United States National Herbarium are three sheets, with many fronds, some (*51169*) conforming to van

den Bosch's description, some (*51170*) of the more typically developed, more dissected form; all are certainly one species.

66. TRICHOMANES CYRTOTHECA Hillebrand. Plate 35, figs. 3 and 4; Plate 37.

Trichomanes cyrtotheca HILL., Fl. Haw. (1888) 636.

Rhizome climbing as in no 3 [*T. davallioides*], wooly with crisp reddish-brown thin translucent hairs of many articulations. Stip. at distances of 1–3′, terete or most faintly margined, 2–4′ long, fibrillose in the lower portion. Frond polystichoid, ovate to ovate-lanceolate, 5–9′ × 3–7′, broadest at the base, firm chartaceous, dull brownish when dry, bi-, tripinnatifid, the rhachis very narrowly margined, often only in the axils, and faintly fibrillose. Primary pinnae 10–14 on a side, stipitate, ascending, ovate to ovate-lanceolate, the longest 2–4½′ long with a short acumination, pinnatifid at acute angles in the upper portion, but pinnate to a faintly margined rhachis nearer the base. Secondary segments or pinnules ascending, narrow ovate-oblong, obtuse, the lowest with a cuneate base and substipitate, their margins cut halfway or more into narrow oblong or obovate lobes which are sharply 2—5-toothed at the top. Veins close, forking, each lobe or segment with 2–9 branches, a few dark striae in the intervals between them. Invol. tubular, slender, about 1″ long, with an expanded bilabiate mouth, *curved,* truly axillary, terminating the first superior veinlet of a lobe, rarely 2 or 3 to a lobe, quite free, stipitate, the thickened tube brown, the lips green. Columella about the length of the tube.

Oahu: in the woods of *Kahuku* and *Kahana.*—Hillebrand, loc. cit.

A relative of *T. davallioides,* distinguished by the deltoid, clear green or olive-green fronds, comparatively wingless axes, and fewer segments. I do not find the curved or flexed sorus constant; Hillebrand emphasized this feature, comparing the species with *T. obscurum, T. elongatum,* etc., to which it is not nearly related. It is like *T. davallioides* in structure, except that in specimens examined the walls are not quite so thin. It seems much less variable than *T. davallioides,* and I do not believe that this appearance is dependent upon our having fewer specimens. The stipe is always elongate, approaching the length of the blade, and slender.

From Maui, I have *Faurie 106, 111, 113, 434,* and *435.* In the Gray Herbarium is a Maui specimen collected by *E. Barclay.* In the United States National Herbarium are *Bartch 65, 68, 73* and *86,* all from "Hillebrand's Glen," near Honolulu, Oahu. "Waiane V.," the source of *Rock 1150,* is presumed to be in Oahu. Christensen, Bishop Mus. Bull. 25: 7, reports it from Hawaii.

Faurie 106 in University of California herbarium, received from Doctor Rosenstock as *T. davallioides* f. *dilatata* Ros., is in part *T. davallioides,* but includes one very large frond so diverse in the color and dissection of different parts that I believe it must be a hybrid, of the chimæra type.

67. TRICHOMANES MAXIMUM Blume. Plate 38, figs. 1 to 4.

Trichomanes maximum BLUME, Enum. (1828) 228; VAN DEN BOSCH, Hymen. Javan. 25, pl. 18.

T. fronde tripinnata ovato-oblonga amplissima, pinnis subalternis oblongo-lanceolatis, pinnulis cuneato-oblongis partito-pinnatifidis, laciniis subdichotomo-partitis, secundariis linearibus subbifidis, rachi omnino alata, stipite elongato inferne teretiusculo glabro.

OBS. Maxime affine *Trichomani meifolio*, Bory et Willd., quod differt frondibus multo minoribus et rachi setosa.

Crescit ad pedem montis Burangrang Javae insulae.—Blume, loc. cit.

Rhizoma validum pennam anserinam crassum horizontale radiculoso-ramosum, ramis parce ramulosis pilis brevibus atris hirsutis; stipites itidem validi approximati, basi terete setis atris hirsuti, hinc teretes illinc canaliculati usque 2½–3 decim. longi apice lineis breviter decurrentibus marginati; frons 2½–4½ decim. longa, 1½–2 decim. lata firma membranacea subopaca olivaceo-viridis ovata vel late ovato-oblonga tripinnatifida vel decomposita . . . .—Van den Bosch, loc. cit.

A species well characterized in general by the scandent rhizome and the large, dark, lax fronds of fairly firm texture, so divided that the axes of the pinnules are winged only to about the width of the segments. This dissection of the pinnules is the most convenient means of distinction from the large forms of *T. radicans*. Besides this, *T. maximum* is more likely to lose the pubescence of the rhizome, is commonly a decidedly larger fern, of firmer texture, and the involucre is not usually at all bilabiate, nor even indented at the sides.

In detail, it is variable, though less so than *T. radicans*. As in that species, the wing of the rachis and stipe may disappear; it may be wanting on the lower or the larger part of the stipe, or may run to the base. The wing of the involucre may be conspicuous or almost wanting. The mouth may be practically truncate, as is common in the Philippines; or slightly dilated, as is usual in Java; or moderately flaring, as in Polynesia; but none of these forms is locally quite constant. The more dilated involucre in the eastern part of the range narrows the gap toward *T. johnstonense*.

Common at lower and middle altitudes in all Malay islands; north to Siam and Formosa; eastward without interruption to Tahiti; and reported in Queensland.

68. TRICHOMANES JOHNSTONENSE Bailey.

Trichomanes johnstonense BAILEY, Proc. Royal Soc. Queensland 1 (1884) 14, pl. 1 (or 2).

Rhizome long, creeping, rigid, knotted, clothed with black bristle-like scales. Stipes somewhat angular, scarcely winged, 2 to 4 in. long, of a dingy brown color, the immediate base scaly as the rhizome. Fronds bipinnate

with deeply pinnatifid or bipinnatifid pinnules, 3 to 6 in. long, 1½ to 4½ in. broad, the rhachis slightly winged, the linear segments very narrow, 1-nerved. Indusia few on the lower lateral segments of the pinnule, free, erect, much tapering towards the base, the orifice two-lipped. Receptacle exserted usually long. Hab. Johnstone River. W. R. Kefford.—Bailey, loc. cit.

This is pictured, without detail, by Domin, Bibl. Bot. 20: 18, 19, who reports it as common in places in Queensland, and observes:

Eine charakteristische Art, die jedoch auf den ersten Blick von den sehr kleinen Formen des *T. maximum* schwer zu unterscheiden ist. Sie ist aber noch viel kleiner, die langkriechenden, rigiden Rhizome sind mit schwarzen Spreuschuppen dicht bekleidet, die Spreite ist höchstens 15 cm lang, die Röhre kurz zweilippig.

Das typische *T. maximum* besitzt dagegen ein starkes, beinahe kahles Rhizom, die Spreiten sind 30–75 cm lang, das Indusium am Ende verbreitet, aber nicht zweilippig.

Bailey's figure is apparently a "lithogram." Domin's is a much-reduced photograph of an herbarium sheet.

I have not seen this plant. Every detail by which Domin would distinguish it from *T. maximum*—size, hairy rhizome, bilabiate involucre—would make it *T. radicans*. Bailey's figure indicates more resemblance to *T. maximum* in the dissection of the pinnules, and does not show the secondary rachises to be winged.

Previously known in Queensland only. By description, I identify as this species a Fiji specimen, *Parks 20196a*. It could be a depauperate *T. maximum*.

Knowing this species by description only, I cannot satisfactorily distinguish from it a fern of the central Philippines which has been distributed several times as *T. speciosum* and as *T. pyxidiferum*. I prepared a diagnosis in 1908, but am still unready to publish a name for it. The description follows.

Rhizomate repente, ca. 1 mm crasso; stipitibus 5 ad 8 cm altis, sursum rhachisque anguste alatis; fronde 10 ad 18 cm alta, lanceolata, tripinnatifida; pinnis oblongis vel ovatis; segmentis ultimis 1 mm latis, ca. 5 mm longis, acutis sed sub lente emarginatis, integris, glabris, venis spuriis carentibus; indusii tubo 2 ad 3 mm alto, anguste cylindrico, alato, oro dilatato et bilabiato; receptaculo exserto.

The nearest affinity is to *T. maximum*, in spite of the details of description, which would bring it nearer to *T. radicans*.

NEGROS, Mount Canlaon, *Copeland 2074*, *Merrill 8028;* Horn of Negros, *Elmer 9878, 10268*. LUZON, Sorsogon, *Bur. Sci. 23549*

Ramos, Elmer 16185, 16937. LEYTE, *Bur. Sci. 15262, 41480 Ramos.* CAMIGUIN DE MINDANAO, *Bur. Sci. 14808 Ramos.* MINDANAO, Surigao, *Wenzel 3444, 3446.* BASILAN, *Bur. Sci. 16201 Reillo,* in part.

69. **TRICHOMANES APHLEBIOIDES** Christ. Plate 38, figs. 5 to 8.

Trichomanes aphlebioides CHRIST, in C. Chr., Index (1906) 635; HOLTTUM, Journ. Mal. Br. Roy. As. Soc. 6 (1928) 18, pl. 4.
T. tenuissimum CHRIST, in Schumann and Lauterbach, Fl. deut. Schutzgeb. in der Südsee (1901) 106, non van den Bosch.
T. pulcherrimum COPEL. in Philip. Journ. Sci. 9 (1914) Bot. 227.

Species maxima, valde composita, laciniis tenuissimis insignis, a *T. apiifolio* Sw. repente frondibus non caespitosis stipiteque setis rufis destituta, rhizomate a *T. maximo* Bl. laciniis valde regularibus tenuissimis textura tenera, a *T. giganteo* Bory laciniis multo angustioribus, a *T. ericoidi* Hedw. cui laciniis tenuibus proximum stipite haud setoso-tomentoso, statura multo majore, textura tenera indusioque margine magis dilatata diversum, rhizomate duro pennae gallinaceae crassitie, repente scandente flexuoso inferne glabrato apice setis nigricantibus parce vestito; frondibus sparsis, stipitibus vetustis remanentibus, frondiferis 15 cm longis firmis erectis nigrescenti-viridibus infra parce pubescentibus, fronde 40 cm longa, 20 cm lata deltoideo-ovata quadri- seu quinquepinnata, pinnis remotis, infimis brevioribus 12 cm longis petiolatis e basi latiore ovato-acuminatis versus apicem decrescentibus apice frondis caudato-acuminato; pinnulis valde regularibus ovato-triangulis, iterum pinnatis, pinnulis III ordinis in lacinias regulares angustissimas, et laciniis infinis saepe iterum partitis; laciniis ultimis vix ⅓ mm latis, 3 mm longis, filiformibus, nervo uno alaque angustissima sub lente solummodo recognoscenda constitutis, setulis minimis raris adspersis. Soris ad basin superiorem pinnularum III ordinis positis, brevissime hispidulis, pedunculatis anguste et cylindraceo-urceolatis saepe incurvis, margine horizontaliter dilatata conspicua, receptaculo modice exserto.

Kaiser Wilhelmsland: Sattelberg. . . . 300–900 m. . . . (Lauterbach n. 494 . . .).—Christ, in Schumann and Lauterbach, loc. cit.

A species of remarkable beauty, rivaling *T. apiifolium* in grace, and even exceeding it in size, characterized by its stout, scandent rhizome, the abortive fronds in the axils of the normal fronds, the finely dissected fronds with exceedingly numerous segments and the tubular involucres with flaring mouth.

Stipes up to 20 cm long; fronds up to 60 cm long and 30 cm wide, usually broadest above the base; rachis very narrowly winged; pinnæ short-stalked, ovate-lanceolate, acuminate, contiguous or imbricate; pinnules ovate, obtuse; secondary pinnules pinnatifid to a narrow wing into simple or cleft segments about 0.5 mm wide, the wing on the lower axes being even narrower than on the segments; nerves fine; texture thin, surfaces sparsely clothed with minute, club-shaped trichomes; laminar cells with

thin, straight walls; involucre cylindrical, with narrow or obsolete wing and conspicuously flaring mouth, 2 mm long in Papua, slightly shorter in Sumatra and Fiji; receptacle long-exserted, but slender and fragile. The abortive fronds, one or two in the axils of each stipe on strongly developed plants, are commonly about 5 cm long, and destitute of lamina (under the naked eye), consisting essentially of the rachises and costæ.

JOHORE, *Ridley*, in 1892. MENTAWI, *Exped. Mentawei 195.* SUMATRA, *Boden Kloss 14516, 14831, Brooks 26*, type of *T. pulcherrimum.* SULA, *Atys 265.* CERAM, *Posthumus 2060.* TERNATE, *Bequin 3351.* PAPUA, *Bamler 55, Rosenstock Fil. Novo-guin. 179, Brass 1041, 1471, Kärnbach 68* as *T. bauerianum, King 193, Lam 570, 1212, Lauterbach 494* (type), *Schlechter 16854, Werner 61.* FIJI, *Parks 20295A.*

It seems hardly credible that so showy a species, ranging from Fiji across Sumatra, and common at least in places, eluded detection until 1900. but I have been unable to recognize it as any earlier species.

70. TRICHOMANES GIGANTEUM Bory.

Trichomanes giganteum BORY ex Willd., Sp. Pl. 5 (1810) 514; HOOKER, Ic. Pl., pl. 702.

T. frondibus triplicato-pinnatis, pinnulis pinnatifidis decurrentibus, laciniis linearibus inferioribus bifidis, superioribus obtusis emarginatis, rachi primaria tereti, secundaria alata. W.

T. frondibus decompositis, stipite canaliculato. *Bory in litt.*

* * * * * * *

Habitat in unica sylva ad lacum magnum insulae Borboniae *in arborum truncis.* ♃. (*v. s.*)

Caudex *crassitie pennae repens tomentosus.* Stipes *quadripollicaris teres canaliculatus glaber.* Frons *sexpollicaris, saepe vero pedalis et longior, circumscriptione oblonga vel lato- lanceolata, triplicato-pinnata.* . . . Rachis *primaria teretiuscula lineis duabus decurrentibus setis tenuissimis valde raris articulatis patentibus instructa; secundaria margine foliaceo alata.* . . .—Bory and Willdenow, loc. cit.

I have no authentic specimen of this species, and feel sure that the wide range which has been ascribed to it, including Malaya and Fiji, is due to confusion with other species. However, there is in the Gray Herbarium a specimen collected by Perrottet in Pondicherry which conforms perfectly to the description. It is distinguished from others of the immediate group by wingless stipe and rachis. The stipe is 13 cm long, the frond more than 40 cm. In dissection and texture it suggests *T. apiifolium.* The involucres are narrowly tubular, sessile but hardly immersed at

the base, moderately dilated but not bilabiate at the mouth. With as much certainty as is ever possible in the identification of *Trichomanes* by description, this is *T. giganteum.*

Specimens from Sikkim, collected by Hooker and Thomson, in the Gray Herbarium, and *Clarke 36382* in the United States National Herbarium, differ from it in having less deeply dissected pinnules and acute segments, but are like it (and unlike *T. radicans*) in having wingless stipe and rachis.

It is not impossible that it bears abortive fronds which have been overlooked.

71. TRICHOMANES SUPERBUM Backhouse. Plate 39.

Trichomanes superbum BACKHOUSE ex Moore in Gard. Chron. (1862) 44, non van den Bosch (1863).

T. hispidulum METTENIUS in Kuhn in Linnaea 35 (1868) 389.

T. ignobile CESATI, Atti Accad. Napoli 7^{8} (1876) 9.

Caudex thick, very short, creeping, chaffy. Fronds triangular-ovate, 2 to 3 feet high, and 1 to 1½ foot wide, tri-quadripinnatifid, dense, deep green, clothed beneath with minute translucent glandular hairs; ultimate divisions short, linear obtuse. Stipes tall, erect, rigid, *margined to the base with a very broad and rather undulated wing,* and like the rachides densely clothed with rough reddish hairs. Involucre subcylindrical supra-axillary, very small, the base sunk in a deflected segment; mouth not spreading nor two-lipped. *Backh. MS.*

This is a Bornean plant, and a very fine one certainly. It is of robust habit with broad triangular plane broad pinnuled fronds, having some resemblance to those of T. Prieurii, and is moreover remarkable for the very broad and well-marked wing which is continued down to the base of the stipes. This noble species was brought to England by H. Low, Esq., jun., and is in the collection of Mr. Day, as well as in that of Messrs. Backhouse.—Moore, loc. cit.

While this description agrees imperfectly with that of *T. hispidulum* by Mettenius, and applies incompletely to that plant, the salient characteristics conform so far that I cannot doubt the identity of the subjects. It is not credible that there is in Borneo another species with notably large deltoid-ovate fronds with hairy rachises and glandular-hairy lamina, and a conspicuously winged stipe, distinct from *T. hispidulum,* and not collected during the past seventy years. The rhizome is erect or ascending, not creeping in the usual sense even if casually prostrate; and no *Trichomanes* has a chaffy caudex.

The most striking feature of the species, at least of well-preserved specimens, is the ciliate mouth of the involucre, crowned by a showy fringe of erect trichomes. A similar feature recurs in *T. blepharistomum* of northern Luzon, to which the resem-

blance in other respects is not close. The laminar cells are notably large, with wavy lateral walls, oblique in places, and uniformly thin—that is, not pitted unless by fine pores.

Trichomanes ignobile was described from sterile material. Microscopic examination of a fragment of the type, showing the characteristic laminar hairs and wavy walls, has established its identity beyond question.

This species is known in Borneo, the Malay Peninsula, and Sumatra, and is too clear-cut to need citation of collections.

TRICHOMANES FARGESII Christ.

Trichomanes Fargesii CHRIST, Bull. Soc. Bot. Fr. Mém. 1 (1905) 10.

Rhizomate indefinite crescente flexuoso ebeneo, pilis rufis vestito postea glabrato funiformi late scandente, frondes numerosas alternas confertas biseriatim emittente, 65 cm. (et ultra forsan) longo, foliis numerosis sessilibus ovato-deltoideis acuminatis 10 cm. longis, 4 cm. latis versus basin latissimis sive paulisper attenuatis, tripinnatifidis, rachi, alata, pinnis pectinato-confertis oblongis obtusis, 1,5 cm. longis, 5 mm. latis costa alata, pinnulis circa utroque latere, profunde dichotomis aut flabellatim furcatis lobis linearibus uninervatis vix 1 mm. latis obtusis, tota fronde pilis longis rufis ciliata.

Urceolis creberrimis solitariis et terminalibus in lobis pinnularum inferioribus positis breviter pedunculatis (pedunculo alato) 1 mm. longis et latis in furca nervi prominuli positis aperte campanulatis ore patente, receptaculo crasso 5 mm. longo exserto. Egregium Chinae decus.

Hab. Su-tchuen or.: distr. Tchen-kéou, 1400 mètres, août, *Farges* 202.—Grimpant sur les rochers humides.

Splendide espèce du port de *Tr. brachypus* Kze, d'Amérique. Distingué par la fronde étroitement partagée, l'urcéole courte, largement ouverte et le réceptacle très long et raide.—Christ, loc. cit.

TRICHOMANES MIYAKEI Yabe.

Trichomanes Miyakei YABE, Bot. Mag. Tokyo 19 (1905) 34.

Rhizoma horizontale repens rigidulum tomentosum. Stipes erectus 10–15 cm. longus glaber sursum anguste alatus. Frons 15–27 cm. longa, 7—11 cm. lata, oblongo-lanceolata stricta flexilis bipinnata.

Pinnae I ordinis alternatae remotae ovato-oblongae acutae (nec acuminatae) 3–7 cm. longae 3 cm. latae basi subinaquilaterales cuneatae. Pinnae II ordinis rhombeo-oblongae v. ovato-oblongae 1½—2 cm longae 1–1½ cm. latae alternatae bipinnatifidae. Lacinulae lineares. 1 mm. latae (in sicco angustiorae) 2–3 mm. longae apice obtusae saepe emarginatae unicostatae membranaceae laete virides glabrae, e cellulis uniformibus mediocribus oblongis contextae. Rachis anguste alato-marginata. Sori in pinnis secundariis axillares pauci; indusium anguste alatum cylindricum limbo recto subangustato. Receptaculum longissime exsertum 7 mm. longum.

Hab. Formosa: Rahau, in jurisdictione Taipe, legit K. Miyake.

T. caudato affine, a quo pinnis remotioribus laminis viridibus nec atroviridibus differt.—Yabe, loc. cit.

72. TRICHOMANES AURICULATUM Blume.

Trichomanes auriculatum BLUME, Enum. (1828) 225; OGATA, Ic. Fil. Jap. pl. 198.

Cephalomanes auriculatum VAN DEN BOSCH, Hymen. Jav. 34, pl. 25.

T. dissectum J. SM., Journ. Bot. by Hooker 3 (1841) 417 nomen; HOOKER, Sp. Fil. 1:140; BEDDOME, Ferns Brit. India pl. 182 (details bad).

T. fronde pinnata lineari-lanceolata glabra, pinnis alternis cuneato-oblongis obtusis basi sursum auriculatis deorsum abscissis multifidis, laciniis truncatis denticulatis, rachi submarginata subpubescente, caudice scandente radicante.

Crescit in Javae rupibus montanis.—Blume, loc. cit.

Rhizoma validum pennam gallinam crassum longissimum teretiuscolum flexuosum parce ramosum scandens, hinc glabrescens, illinc tomento fusco densissime vestitum . . . sori in lobulis pinnarum angustatis abbreviatisque laterales semiimmersi, indusio mediotenus fere anguste marginato cylindrico plerumque incurvo vix conspicue ventricoso . . . cellulae tenerae diaphanae parvae, imo mediocres . . . parietibus hyalinis rectis modice incrassatis.—Van den Bosch, loc. cit.

A well-defined species, recognizable by the stout, long-scandent rhizome and simply pinnate fronds. The stipes vary from obsolete to 2 cm long. The fronds are up to 40 cm long and 5 cm wide, commonly 25 cm long and 3.5 cm wide, acuminate; rachis narrowly winged; pinnæ dilated on the upper side at the base, whence the name, acute to broadly rounded at the apex, irregularly incised, sometimes shallowly, sometimes well toward the costa, forming toothed lobes; sori, in full fruit, on both sides of the pinnæ; involucre truncate or notched on the sides, slightly dilated at the mouth in Java and the Philippines, more so farther north, narrowly winged in Java and the Philippines, more evidently so in China and India, broadly in some Japanese specimens.

Java, Sumatra, Malay Peninsula, common; Borneo. New Guinea, *Bamler 27*. Philippines, common; *Cuming 159*, the type collection of *T. dimidiatum* Presl and *T. dissectum* J. Sm., is typical enough *T. auriculatum*. Southern China; Himalayas from Assam to Northwest provinces; Formosa, Loo Choo, Onsima (*Wright*), Japan.

10. THE GROUP OF TRICHOMANES GRANDE

Terrestrial species with erect caudex and long, fascicled stipes; rachis and upper part of stipe normally narrowly winged, but the wing often caducous; fronds quadripinnatifid, with linear but not setaceous segments, bearing clavate trichomes; veins fine; cellu-

lar structure simple and uniform, with small cells, and thin, straight walls.

Three similar species common over the Malay-Polynesian area, long confused with the *T. rigidum* group and with *T. maximum*, and related to the latter.

Key to the species.

Mouth of involucre more or less dilated, naked.
  Frond narrowly ovate .... 73. *T. grande.*
  Frond round-ovate .... 75. *T. intermedium.*
Mouth of involucre truncate and ciliate........................ 74. *T. blepharistomum.*

73. TRICHOMANES GRANDE Copeland. Plate 40, figs. 1 to 4.

T. grande COPELAND, Philip. Journ. Sci. 6 (1911) Bot. 70.
T. millefolium PRESL, Hymen. (1843) 135?; VAN DEN BOSCH, Hymen. Javan. 27, pl. 20; non Desvaux (1827).
T. anceps var. β HOOKER, Sp. Fil. 1 (1846) 135, pl. 40C, fig. 3.
T. elatum VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 177, non Forster (1786).

Rhizomate erecto, stipitibus confertis, alatis, 20 cm altis; fronde 20–35 cm alta vel ultra, 10–15 cm lata, quadripinnatifida, rhachibus alatis, sparse puberula; segmentis ultimis 0.5 mm latis, planis, obtusis; soris paratactis, indusio utroque latere subcarinato, infundibuliforme, limbo dilatato et interdum subrevoluto.

Philippines: *Copeland 1739* (type) . . . Papua. . . .

This was included with some other species in *T. anceps* Hooker. *T. millefolium* Presl was based on another plant, also included in *Cuming 162*, which is *T. maximum* Bl. This is more like *T. rigidum* Swtz. which however is a much smaller plant, less divided, with shorter indusium, and is very doubtfully present in the Orient.

The Papuan specimen has much broader pinnae than those of the Philippines; . . .—Copeland, loc. cit.

Presl's *T. millefolium,* was described with "Rhizoma lineam crassum, repens, flexuosum, glabrum, lignosum," which if accurate must apply not to this plant but to *T. maximum.* The only specimen cited was *Cuming 162,* of which all the specimens I have seen have an erect rhizome and fascicled stipes. The same collection typified Hooker's *T. anceps* var. β, and was cited by van den Bosch, following a Sumatra specimen, in the publication of his *T. elatum.* The long failure of this common low-country fern to receive a tenable name is not more remarkable than the variety of species with which is has been confused. To correct the errors which must have entered herbaria by the distribution of misnamed specimens, I will cite such collections, the

names in parenthesis being those of the distribution; if no such name is given, the name distributed was *T. maximum.*

PHILIPPINES: *For. Bur. 1242, 1768 Borden, For. Bur. 2421 Meyer* (*T. meifolium*); *Whitford 274, 440, 720, 1604* (*T. rigidum* and *T. millefolium*); *Copeland 204* (*T. rigidum* and *T. maximum*); *Merrill 3115; Topping 435, 446, 715, 811; For. Bur. 8893 Curran; Matthew* (*T. millefolium*); *Merrill, Phil. Plants 632* (*T. bauerianum*); *For. Bur. 9540 Curran* (*T. rigidum*); *Bur. Sci. 6849, 9327, 9352, 9488 Robinson; Elmer 9050* (*T. bauerianum*); *Copeland 2008; Bur. Sci. 13096 Foxworthy and Ramos; Bur. Sci. 3133 Mearns; Bur. Sci. 22071 Ramos* (*T. rigidum*); *Bur. Sci. 10289 McGregor* (*T. radicans* and *T. bauerianum*); *For. Bur. 6774 Merritt* (*T. rigidum*); *For. Bur. 12086 Merritt; Merrill 6060; Elmer 9933; Bur. Sci. 18500 McGregor* (*T. rigidum*); *Wenzel 259* and *Bolster 344* (*T. rigidum*); *Bolster 269* (*T. apiifolium* and *T. bauerianum*); *For. Bur. 9317 Whitford and Hutchinson; Copeland 1671* (*T. obscurum*); *Micholitz s. n.; Wilkes Exped. 18* (*T. maximum* and *T. anceps* β). JAVA, *Bache 8827; Raciborski s. n.; B. v. d. Brink 4198.*

The Papuan plant referred to in the publication of *T. grande* is to be referred rather to *T. intermedium.*

74. TRICHOMANES BLEPHARISTOMUM Copeland sp. nov. Plate 41.

T. terrestre frondibus fasciculatis magnis, quadripinnatifidis segmentis linearibus pilis clavatis aspersis, involucris cylindricis alatis truncatis ore more T. superbi ciliatis, aliter T. grandi omnino simile.

LUZON, Cagayan Province, Kilingkiling River, *Bur. Sci. 79659 Edaño,* type in herb. Copeland *14440;* also *Bur. Sci. 79655, 79656 Edaño; Bur. Sci. 7560, 7569, 14548 Ramos; Weber 1558,* all from Cagayan. BATAN ISLAND, *Bur. Sci. 80338 Ramos.* All distributed as *T. rigidum* or *T. grande.*

The club-shaped trichomes are deciduous, leaving no certain trace on old specimens; but these can still be distinguished from *T. grande* by the truncate, tubular, winged involucre. Without fruit, the two are not distinguishable.

Judging by the name, this seems likely to be *T. thysanostomum* Makino, nomen nudum—nomen nudum not because published in Japanese, but because not described in any language. What is said about it is translated for me by a Japanese as, "This little fern, commonly called kashu in the Liu Kiu Islands, I identified previously as *T. apiifolium* Presl, but afterward found that this was an error."

75. TRICHOMANES INTERMEDIUM van den Bosch. Plate 40, fig. 5.

Trichomanes intermedium VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 179; Journ. Bot. Néerl. 1 (1861) 361, non Kaulfuss, nomen nudum.

T. Harveyi CARR., Flora Vitiensis (1873) 344.

T. maximum var. *grandiflora* ROSENSTOCK, Fedde's Repert. 5 (1908) 371.

T. intermedium (*T. anceps* β BRACK. (non Hook.) *in Wilkes* Expl. Exp. XVI *p.* 258), Fronde e basi cuneata latissime rotundatâ cordato-ovata decomposita, laciniis primariis e basi erecto-patula mox divergentibus recurvisque imbricatis late oblongis acuminatis (summis lanceolatis) tripinnatifidis, secundariis patulo-divergentibus remotis (infimis imbricatis, summis distantibus) e cuneato oblongis apice productis bipinnatifidis, tertianiis subpatulis infimis contiguis, sursum sensim magis remotis oblongis linearibusve pinnatifidis, ultimis remotis anguste linearibus elongatis, lacinulis angustis brevibus strictis apice subrecurvis, rhachi venisque teretibus anguste alatis, cellulis opacis firmis parvis minimisque subelongato-hexaëdris, parietibus fere inconspicuis rectis, interaneis amorphis spissis obscure fuscis, marginalibus minimis subtetra-semihexaëdris, soris in laciniis ultimis axillaribus exsertis mediocribus, indusio anguste cylindrico leviter ventricoso, subito in limbum amplum (tubo ter latiorem) undulatum subreflexum dilatato, stipitibus fasciculatis, e rhizomate brevi adscendente polyrrhizo, ultra medium anguste alatis 10–15 centim. longis. Frons usque 2½ decim. longa, basi 2–2½ decim., medio 18 cent. lata rigidiuscula angustissime membranacea olivacea.

. . . Inter *T. maximum* et *T. Millefolium* medium . . .

Hab. Ins. Fidchi Oualao), WILKES.—Van den Bosch, Ned. Kruid. Arch. 5 (1861) 179.

It seems not to have occurred to van den Bosch that this species and his *T. elatum,* described two pages earlier, needed to be distinguished, but they are really so near together that aberrant fronds of each completely simulate the other. Under the microscope, they are alike; but the difference in frond form holds with reasonable constancy throughout the area occupied by each species. *Trichomanes intermedium* has relatively wide fronds and relatively long stipes. Less constantly, the branching of *T. intermedium* is more divaricate, so that, according to the varying ampleness of the fronds, they are either more lax or have the pinnæ and pinnules more imbricate; the angle is more uniform, making the fronds more symmetrical; and the dilation of the mouth of the involucre is usually greater.

PAPUA, *King 351; Lam 815; Werner 51; Rosenstock, Fil. novoguin. 7; Brass 1040* (as *T. grande*). FIJI, *Brackenridge 18;*[10]

[10] The Wilkes (U. S. Exploring) Expedition numbers are publication numbers; thus, this "No. 18" refers to all collections given the same name, from Tahiti (?), Samoa, Fiji, and Luzon.

Horne 72; Prince; Parks 20137, 20190, 20224, 20228, 20294, 20295 in part, *20420* (all as *T. Harveyi*) ; *Gillespie 2202, 2636.* SAMOA: *Brackenridge; Powell; Graeffe; Betche; Prince; Reinecke 43a* and *b; Safford 49, 958; Setchell 218.* Most collections distributed as *T. maximum.* Reported from Tahiti by Brackenridge, and a specimen in the United States National Herbarium is so labeled; but I suspect confusion as to its source.

11. THE GROUP OF TRICHOMANES APIIFOLIUM

Caudex erect or suberect; stipes and rachises terete, conspicuously bristly; fronds large, thin, quadripinnatifid with narrow but not filiform or setaceous segments; cells with uniformly thin walls. Typically epiphytes. Geographical range, Malaya across Polynesia.

Key to the species.

Fronds normally more than twice as long as wide.
  Involucre truncate, obconic.
    Involucre narrowly winged .... 76. *T. apiifolium.*
    Involucre broadly winged .... 77. *T. bauerianum.*
  Involucre subbilabiate .... 78. *T. polyanthum.*
Fronds normally less than twice as long as broad .... 79. *T. Baldwinii.*

76. TRICHOMANES APIIFOLIUM Presl. Plate 42, fig. 1.

T. apiifolium PRESL, Hymen. (1843) 108 (nomen), 136; VAN DEN BOSCH, Hymen. Jav. 26, pl. 19.
T. eminens PRESL, Hymen. (1843) 108.
T. myrioplasium KZE., Bot. Zeit. 4 (1846) 477.
T. exaltatum BRACKENRIDGE, U. S. Expl. Exped. 16 (1854) 259.
T. meifolium BLUME, HOOKER, et al., non Bory.
T. bauerianum BAKER, C. CHRISTENSEN, et al., non Endlicher.

T. fronde glaberrima oblongo-lanceolata acuta tripinnata, pinnis lineari-oblongis pinnulisque anguste oblongo-lanceolatis petiolulatis acutis, secundariis anguste linearibus obtusis, infimis subbifidis, soris exsertis pedicellatis, indusii turbinati ore truncato, receptaculo setaceo indusio duplo longiore, stipite tereti rachibusque villoso, primaria apice secundariis tertiariisque alatis, rhizomate crasso lignoso obliquo frondes aggregatos gerente.

Cuming pl. exs. philip. n. 137 *et n.* 190.

Habitat in insulis philippinis, verosimiliter in insula Luzon, ubi legit clar. Cuming.—Presl. loc. cit.

Presl's detailed description may be omitted, as it applies to ill-developed specimens. He described the plant in its full development as *T. eminens.*

Caudex ascending or erect, the apex immersed in reddish-brown bristles commonly 5 mm long, bearing a mass of stout roots and stipes; stipes commonly 10 cm long and 2 mm thick, sometimes up to 20 cm long and 3 mm thick, terete, dark brown,

densely beset with horizontal bristles commonly 5 mm, rarely 8 mm long, rough in age as these are lost; frond up to 45 cm long and 18 cm wide, acuminate, the base rarely truncate, usually abruptly narrowed, with one or a few pairs of moderately reduced basal pinnæ, quadripinnatifid when well developed, with numerous pinnæ and pinnules usually imbricate; rachises of frond and pinnæ wingless toward the base; axes of pinnules and their divisions equally winged to a total width of commonly 0.5 mm; secondary pinnules commonly 5 on a side, the basal ones forked or with 3 or 4 segments; ultimate segments 4 to 6 mm long, obtuse; cell walls uniformly thin, and nearly straight; sori on shortened acroscopic basal secondary pinnules or segments, small, involucre turbinate with acute base and truncate apex, 0.6 to 1.2 mm long, 0.6 to 1.0 mm wide, with a wing narrowed at the base and disappearing at the apex.

The showiest Philippine *Trichomanes* and the most-collected species of the tree-fern and mossy-forest regions—there have been some sixty numbered distributions. It is moderately variable locally, as with long- or short-acuminate pinnæ with one or two or three pairs of reduced basal pinnæ, in the width of the segments, etc. Very large fronds usually produce larger sori than small fronds. There are also recognizable geographical races; thus the typical plants of central Luzon have sori 0.6 to 0.8 mm long and wide, while those of northern Luzon and of northern Mindanao have sori more than 1 mm long. The fertile segment is usually slightly constricted below the sorus; specimens from Mount Halcon, Mindoro, *Merrill 6073*, are so narrowed there that the sorus is practically stalked.

The range of variation in the Philippines blankets that in the Malay region, and east as far as Fiji, except as the cells of the lamina are commonly rather larger and the pinnæ are broader in the eastern part of the range. It is apparently rare in Borneo and in Sumatra, but commoner in Java. The few Papuan collections are identical with Philippine, and the same is essentially the case with those of the New Hebrides and Fiji. In Samoa, it is more variable, the involucres ranging from 0.7 to 1.2 mm in length, but it is still easily the same species. In Rarotonga there is some tendency toward a development of a web in the axils of the pinnules, producing a lamina broader than that of the segments; the pinnules are longer and the pinnæ therefore wider than is typical; and the wing of the in-

volucre is decidedly variable. Still I am disposed to treat it as the same species.

Elsewhere in Polynesia the local strains are divergent enough so that it seems best to conserve the measurable uniformity of the wide-spread species by treating the local forms as distinct.

77. **TRICHOMANES BAUERIANUM** Endlicher. Plate 42, fig. 2.

Trichomanes bauerianum ENDLICHER, Prod. Fl. Norfolk (1833) 17.

Fronde elastica ovato-lanceolata pinnata, pinnis bipinnatifidis, laciniis lineari-lanceolatis acutis, rhachi tereti hirta, involucris turbinatis alatis, ore integro.

Crescit in insula Norfolk. (Ferd. Bauer)

Species habitu Hymenophyllum scabrum *A. Rich. Fl. Nov. Zeel. t.* 14. *f.* 1. referens, Trichomani angustato Carmich. (*Hook et Grev. ic. t* 166.) proxime affinis, notis allatis facile distinguenda. Radix dense caespitosa, fibrosa, fibris rigidis flexuosis intortis. Stipites ex eadem radice plures erecti, stricti, teretiusculi, 3–4 pollicares, juniores pilis rufis tenuissimis fere 3 lineas longis obsiti, adultiores basi tantum pilosi, apicem versus nudi, subtilissime muricato-tuberculati. Frondes ovato-lanceolatae, 8–10 pollices longae, 5–6 pollices latae, elasticae, rhachi communi partialibusque hirtis, caeterum glabrae, pinnatae. Pinnae elongato-lanceolatae 3–4 pollicares, approximatim alternae, pinnatifidae, laciniis oppositis lanceolatis acutis. Sori in laciniis costae contiguis abbreviatis terminales. Involucrum turbinatum, basi attenuatum, utroque margine e fronde continua late alatum, ore truncato. Receptaculum exsertum, basi capsuliferum.—Endlicher, loc. cit.

I have seen no original specimen of this species, and would not distinguish it confidently by the diagnosis; but specimens in the United States National Herbarium, herbarium at Singapore, herbarium of the Bureau of Science, herbarium of the University of California, and my own herbarium, collected by Cunningham, by Robinson, and without data, seem all to represent a local form, conveniently distinguishable from the wide-spread *T. apiifolium*. It has the broad pinnæ and large cells of *T. apiifolium* in its atypical Polynesian form. It is usually less finely dissected, the segments being about 1 mm wide, but this is not constant. The sori, also, are commonly broader and mostly a millimeter or more in length. The most fixed peculiarity is that the involucre is immersed in the end of a short segment, and therefore broadly winged. Its mouth is either perfectly truncate or notched at the sides, thus varying in the direction of *T. polyanthum*.

Specimens from Lord Howe Island, distributed from the Botanic Gardens, Sydney, are intermediate between *T. bauerianum*

and *T. polyanthum,* and inconstant in character even on single fronds; some involucres are even narrowly winged, as in *T. apiifolium;* many are broadly winged on the basiscopic side and narrowly on the acroscopic; and many are immersed, as in *T. bauerianum.* The mouth is notched, or very shallowly bilabiate, never as distinctly as in *T. polyanthum.* The sorus is large for the group, 1.2 to 1.8 mm long. This material might be regarded as a local species; but I prefer to keep the number of such entities down, by construing it as a local variant of *T. bauerianum.* The Tahiti plant mentioned under *T. polyanthum* has gone still a step farther along the line leading to that species, as represented in Huahine and Raiatea.

78. TRICHOMANES POLYANTHUM Hooker. Plate 42, fig. 3.

Trichomanes polyanthum (errore *polyanthos*) HOOKER, Ic. (1848) No. 703.

Hymenophyllum polyanthum HOOKER, in Nightingale, Oceanic Sketches (1835) 132.

Hymenophyllum *polyanthum, n. sp.;* alatum, rigidum, fronde lanceolata pinnata, pinnis profunde bipinnatifidis, laciniis attenuatis integerrimis obtusis, involucris copiosis axillaribus lato-urceolatis nitidis, ore valde membranaceo dilatato obtuse bilabiato, stipite rachique (superne alata excepta) setosis.—Hooker, in Nightingale. [Locality not stated, but probably Huahine.]

Caudex short, erect, beset with reddish brown bristles about 4 mm long; stipes tufted, up to 10 cm long, remarkably stout, bristly, like the rachis, or rough after the bristles fall; frond up to 55 cm long and 16 cm wide, narrowed to both ends, quadripinnatifid, with linear segments hardly 1 mm wide, the minor axes narrowly winged; involucre 2 mm long, 1.6 mm wide, with two broad, short lips. Recently collected in Huahine (*Grant 5325*) and Raiatea (*Moore*). Reported also from Tahiti, from which island our specimens (*Vesco; Grant 3915*) have a smaller involucre, of the same shape.

This species was reduced by Hooker and Baker, Synopsis 86, to a variety of *T. apiifolium,* and by Christensen, Index, accordingly, to a variety of *T. bauerianum.* It is sufficiently distinguished from both by the form and size of the involucre, and the long series of gradually reduced basal pinnæ, the lowest only 1 to 2 cm long.

79. TRICHOMANES BALDWINII (Eaton) comb. nov. Plate 42, figs. 4 to 8.

Hymenophyllum Baldwinii EATON, Bull. Torr. Bot. Club 6 (1879) 293.

T. meifolium HILLEBRAND, Flora 637, non Bory.

Subspithamaeum: frondibus lanceolatis vel ovato-lanceolatis laete viridibus tenerrimis bi-tripinnatifidis; pinnis primariis oblique-divergentibus plerumque rachi anguste alatae adnatis inferioribus solutis; pinnulis simplicibus vel in segmentis paucis oblongis obtusis emarginatisve margine integerrimis nudis divisis; segmentis infimis cujusdam pinnulae abbreviatis apice soriferis; involucris subrotundis fere ad basin usque brevem alatam bilobis, lobis integerrimis, receptaculo columnari; stipite brevi rachique basin versus pilis rufis subulatis hispidis.

Abundant in a little valley in Oahu, at 2,500 feet above the sea; Hon. D. D. Baldwin, 1878.—Eaton, loc. cit.

Caudice erecto vel adscendente, apice setis castaneis immerso; stipitibus fasciculatis, plerumque ca. 10 cm altis, rhachibusque setis castaneis usque ad 4 mm longis horizontalibus vestitis in vetustate asperulis; fronde 15 ad 25 cm longa, late ovata, tri-quadripinnatifida; pinnis subsessilibus, imbricatis, lanceolato-ovatis, rhachibus anguste alatis; segmentis typice 0.7 mm latis, 2 ad 3 mm longis, herbaceis; cellularum parietibus rectiusculis tenuibus; soris in apices segmentorum lateralium brevium immersis, involucro obconico, plerumque 1 mm longo v. longiore, truncato vel saepius subbilabiato.

HAWAII, *Heller 2179,* in *Herb. Univ. Calif. 150243,* "collected on the island of Oahu, on the lower slopes of Konahuanui, above Manoa, on the ground." Other collections are *Heller 2741, 2816; Mann and Brigham 275; Faurie 101; Safford 886; Hitchcock 14797;* and distributions without collector's number by Brackenridge, Hillebrand, in great variety by Baldwin, and by others. On all the larger islands of the group.

This is a typical Hawaiian fern, varying widely, as do so many of the local species. There are two principal forms; one, compact, with comparatively broad segments and conspicuously setose axis; the other, comparatively finely dissected and naked, usually larger, and often with smaller sori and narrowly winged involucres. Hillebrand reports one specimen in which "the segments consist of the vein only, with a border of tissue in the axils." The involucre is never as strongly bilabiate as in typical *T. polyanthum,* nor so large; but it does vary from perfectly truncate to distinctly notched on the sides, and the variation in the wing covers the range from typical *T. apiifolium* to typical *T. bauerianum.* The pinnæ are in general broader than in any relative, but are approached in this respect by the other species in Polynesia. The best ready distinguishing character is the form of the frond. This is naturally not perfectly constant, but I find less than one frond in twenty of *T. Baldwinii* which is

more than twice as long as broad, and less than one in fifty (uninjured) of the other species in the group of which this is not so.

Hymenophyllum Baldwinii was described from small specimens with unusually cleft involucres. For recognition of its identity with the better-developed specimens, *T. meifolium* of Hillebrand and other students of Hawaiian ferns, I am indebted to Dr. H. L. Lyon. I had taken the latter for a new species; and print my diagnosis, prepared under this misapprehension, because it describes the species in its normal development better than does Eaton's. The small form, as far as known, is very local, in the mountains back of Honolulu.

12. THE GROUP OF TRICHOMANES RIGIDUM

Stipes clustered, commonly shorter than the fronds, wingless, axes deciduously hairy, with dark hairs under 2 mm long; fronds mostly ovate with broad bases, firm or harsh in texture, commonly so dissected as to leave the pinnules with an undivided laminar body much broader than the segments, the veins closely parallel in this lamina, and diverging into the segments; laminar cells with thick, pitted walls; involucres cylindrical.

Very common terrestrial ferns of some size, in all warm lands. *Trichomanes rigidum,* which typifies the group, was described from Jamaica. Some of the local species, as *T. longicollum,* have salient characteristics; but the common and wide-spread species are so alike that Hooker was unusually justified in combining them. Müller and van den Bosch thought they found tangible and constant microscopic peculiarities; but, after examining very many specimens of most of the species in great detail, I am satisfied that no other sharp line can be found separating *T. rigidum, T. mandioccanum, T. cupressoides, T. obscurum, T. dentatum,* and *T. elongatum,* save those that can be drawn on a map.

Although more distinct than several groups which have been given generic names, this one seems to have no distinctive name of any rank. *Trichomanes rigidum* was included in Presl's group or subgenus *Pachychaetum,* but that must be typified by *T. luschnatianum,* of the group of *T. radicans.*

Key to the species.

Sori long-stipitate.
- Pinnæ and pinnules imbricate.. 83. *T. longicollum.*
- Pinnæ and pinnules not imbricate.............................. 84. *T. extravagans.*

Sori subsessile, sessile, or subimmersed.
  Rachis narrowly winged throughout.
    Fronds more than 12 cm long.
      Frond narrowed at base .... 88. *T. stylosum.*
      Frond broadest at base............................ 89. *T. batrachoglossum.*
    Fronds less than 8 cm long.................................... 85. *T. tereticaulum.*
  Rachis winged toward apex only.
    Rachis and stipe sulcate.. 86. *T. cupressoides.*
    Axes terete or nearly so.
      Walls wavy, only moderately thick............ 87. *T. mandioccanum.*
      Walls very thick, not wavy.
        Tips and segments normally flat.
          Uncut lamina of pinnules oblanceolate.
          82. *T. elongatum.*
          Uncut lamina linear to elliptical........ 81. *T. dentatum.*
        Tips and segments commonly curled........ 80. *T. obscurum.*

80. TRICHOMANES OBSCURUM Blume. Plates 43 and 44.

T. obscurum BLUME, Enum. (1828) 227; VAN DEN BOSCH, Hymen. Javan. 23, pl. 17.
Didymoglossum longisetum PRESL, Hymen. (1843) 23 (nomen), 49.
T. papillatum K. MÜLLER, Bot. Zeit. 12 (1854) 751.
T. saxatile MOORE, Gard. Chron. (1862) 45.
T. racemulosum VAN DEN BOSCH, Ned. Kruid. Arch. 5^2 (1863) 210.
T. siamense CHRIST, Bot. Tidsk. 24 (1901) 103.
T. latipinnum COPELAND, Philip. Journ. Sci. 6 (1911) Bot. 71.
T. englerianum BRAUSE, Bot. Jahrb. 56 (1920) 37.

T. fronde bipinnata ovato-oblonga glabra, pinnis suboppositis lanceolatis, pinnulis sessilibus cuneato-oblongis profunde pinnatifidis, laciniis linearibus apice inciso-dentatis, rachi stipiteque teretibus subpubescentibus.

OBS. *Trichomanes bifidum*, Vent., cui simillimum, differt laciniis omnibus bifidis indusiorumque receptaculis multo brevioribus; *Trichomanes tamarisciforme*, Jacq. autem laciniis obtusis et forsan integerrimis; affine etiam *Tr. rigido*, Sw., sed laciniis haud lanceolatis distinctum.

Crescit in sylvis montanis humidioribus Javae et Moluccarum.

Var. B. *Obtusiusculum*, pinnulis trapezoideo-oblongis obtusis, laciniis cuneatis apice dentatis.

Crescit in Javae montosis Salak.

Var. C. *Adnatum*, pinnulis adnatis subbipinnatifidis, laciniis linearibus apice dentatis.

Crescit ad ripas fluviorum in syvis Javae occidentalis.—Blume, loc. cit.

This species has received careful analytical study by Karl Müller, Bot. Zeitung 12 (1854) 745–751, and van den Bosch, Hymen. Javan. (1861) 25, pl. 17. Müller contrasted it with "*T. rigidum* Hooker" as to the plant of Mauritius and Bourbon, which he distinguished as *T. achilleaefolium* Bory ex Willd. Van den Bosch's first observation as to *T. obscurum* is "species statura et divisione frondis insigniter ludens. Tales lusus sis-

tunt varietates *obtusiusculum* et *adnatum* BL." Except as some of the minute species (*bipunctatum* and *humile*) may exceed it in number of individuals, this is the commonest terrestrial *Trichomanes* throughout the Malay region, and varies as might be expected of so common a fern.

The stipes are commonly so densely fascicled that no caudex is visible; or its oldest remnant may project at the base or side of a mass of stipe bases, where it has outlasted these bases. Frequently, too, such a mass of stipe bases is just open enough to reveal glimpses of a rhizome, which is 2 to 3, rarely 4 mm in diameter, usually contorted, and clothed at the apex with black bristles 1 to 2 mm long. Commonly near the upper end of the Malay Peninsula, more rarely elsewhere (Java, *Raciborski;* Mindanao, *Copeland 1109*), the stipes are remote enough to leave the rhizome really evident. The stipes are terete, stout, commonly 8 cm tall, rarely up to 22 cm (Amboina, *Tornasi 1160;* this collection is also remarkable for a frond with radicant tip). The stipe and the terete part of the rachis are setose with short, deciduous, reddish-black bristles. Toward the apex the stipe is usually winged. On large specimens the rachises of the pinnæ are terete near the base; they are winged toward the apex, and throughout on small specimens.

The frond is commonly a half longer than the stipe; rarely shorter than the stipe; not commonly more than twice as long. A common size of well-developed fronds is 12 cm long by 10 cm wide. Small specimens and juvenile specimens have relatively narrow fronds. The smallest fruiting fronds observed are *Clemens 1213* from Mindanao, 3 cm long by 2 cm wide, on a stipe 2 cm long; and *Robinson 6348,* from Camarines, Luzon, 5 cm long by 2 cm wide, on a stipe 2 cm long. These small specimens usually have small sori, and the fronds are, of course, simple in some proportion to their size. Without seeing authentic specimens, I suppose that *T. saxatile* Moore and *T. racemulosum* van den Bosch, both described from Borneo, are dwarf specimens of *T. obscurum.* Neither can be distinguished by description from such small specimens as I have seen, and both belong certainly in this group. *Trichomanes Warburgii* Christ, Monsunia 1 (1900) 55, may be like these or may be a small form or relative of *T. grande.*

Trichomanes siamense Christ, Bot. Tidsk. 24 (1901) 103, described as differing from *T. rigidum* in having a lanceolate-ovate frond, with short pinnules and pinnæ, is probably another of these small forms of *T. obscurum.* Its blackish color and co-

riaceous texture indicate that it belongs here rather than with "*T. millefolium* Presl."

Trichomanes englerianum Brause, Bot. Jahrb. 56 (1920) 37, is another name for these small, relatively narrow forms of *T. obscurum,* this time from New Guinea. The sori are larger than typical; otherwise, there is no item in its long description to make one suspect that it is different from *T. racemulosum* or *T. siamense.* Microscopic examination of the type collection, *Ledermann 11026a,* shows complete structural identity with *T. obscurum.*

The frond is normally bipinnate, with lacerate pinnules. In the form and the dissection of the pinnules, the greatest diversity occurs. Most commonly, they are deeply incised at the base, and dentate at the apex, with all teeth and segments acute. As the pinnule narrows from base to apex, its undissected middle strip is more or less of one width throughout (as also in *T. dentatum*).

Trichomanes papillatum K. Müller is a form occasional in the Philippines, with narrow, falcate pinnules, toothed but not incised. It intergrades with the typical plant, and is not a geographical form or strain. It was based on a Cuming collection, without citation of number; "*T. rigidum* Hook. . . . planta Cumingiana" must refer to Species Filicum I: 134, where the citation is "*Cuming n. 134 and 189.*" Müller, in his preliminary comparison with *T. obscurum,* wrote, "Eine von Cuming auf den Philippinen (?) gesammelte Art (weicht) sofort durch einen sehr zarten und schmalen, zweifach gefiederten Wedel ab, dessen einzelne Fiedern wiederum ausserordentlich schmal sind." This fits *189* and not *134* in the United States National Herbarium, Gray Herbarium, and herbarium at Singapore. The Bureau of Science herbarium, and my own, have both forms in *134;* and *189* also is mixed in the Bureau of Science herbarium. But *189,* however peculiar in appearance, is only an ill-developed representative of perhaps the commonest species in the Philippines. There is no line at all between it and the most ample forms of *T. obscurum;* and it is common for this form and more amply developed plants to appear in the same collection.

The form of the laminar cells is as variable as that of the pinnules, and to some extent correlated therewith. The veins fork at a very acute angle, the branches running at first closely parallel. Between these veins, the laminar cells tend to be elongate and quadrilateral. If the pinnules are not much dissected, so that there is a relatively considerable intact area with many

parallel veins, this form of cell predominates and gives character to the frond. Toward (not in) the margins, and in the axils of the segments, the cells tend to be isodiametric and irregular or hexagonal; and in more dissected fronds, and especially in those of lax venation, this general type of cell predominates and seems to be characteristic. The structure of the wall is reasonably uniform. All walls are very thick. As a whole they are straight or curved, but not wavy; this may be seen by viewing them with low magnification, or with high magnification a little out of focus. The volume of these walls is about half occupied by pits, each extending less than halfway through the (lateral) wall, and more or less as broad as deep. The solid median part of the wall may be straight, with the wall between adjacent pits appearing, in exact focus, as projecting teeth, rods, or spines; or it may be moderately deflected if the pits are very deep and their bottoms tend to be crowded between the bottoms of the pits of the adjacent cell. But this solid median part of the wall of typical plants does not become regularly wavy or zigzag, "fulmeni formiflexuosis seu crenatis," as Müller expressed it; as it does in some related American and African species, and in *T. setaceum.*

The sori are commonly borne on the lowest acropetal segments of the pinnules. If the fruiting is luxuriant, a pinnule may bear several sori. The involucre is cylindrical with an acute base, the apex truncate, or slightly notched. It is usually very narrowly winged to the top, the wing being broader at the base. The lamina of the segment is sometimes narrowed below the sorus, but the sorus is never really stalked. The receptacle is far-exserted, two to four or more times the length of the involucre, and is usually curved.

Trichomanes obscurum has its center of distribution in the Malay region, and ranges to Ceylon, India, Formosa, and Papua.

Trichomanes latipinnum Copeland, described from Papua, is a form with remarkably broad pinnæ and pinnules, the latter deeply dissected, and persistently hairy axes. Its sori are mostly more broadly winged than in common *T. obscurum,* but this is inconstant. As a single collection, it looked quite distinct, but I believe now that it intergrades with the typical form. *Burkill and Holttum 8465,* from Pahang, is very similar in form and dissection.

Variable in every land from which we have collections enough to be likely to illustrate its variability, *T. obscurum* is distinctly richer in forms in the Malay Peninsula than in the

Philippines, Borneo, or Java. It has just been noted that a form with wide pinnæ is found here. There are two notable forms with pinnæ atypically dissected. One of these has been confused with *T. setaceum*, but has fewer elongate segments, and these are more restricted to the bases of the pinnules. If of the normal size of *T. obscurum*, these have its typical structure. Although commonest on the Peninsula, such plants are occasionally collected throughout the Malay region and in the Philippines; Philippine examples are *Bolster 219*, from Mindanao; *Bur. For. 19067 Curran*, from Negros; and *Bur. Sci. 7561 Ramos*, from Cagayan, Luzon. They intergrade with the type of *T. obscurum*, but I have not found that they do so with *T. setaceum*. The deviation, however, is in the direction of that species, and of the *Pluma* group.

The majority of the Peninsular specimens with this type of dissection are small plants. Correlated herewith, whether they be regarded as young plants, as aberrant individuals, or as representatives of a distinct strain or even species, is the fact that they are more herbaceous than is typical *T. obscurum*. A further correlation is probably presented by the structure of the lateral walls, which tend to be wavy or zigzag, another deviation in the direction of *T. setaceum*. Examples, citing Singapore field numbers, are *16027*, *16200*, and *20775*, from Pahang; *9611*, and two unnumbered collections by Ridley, from Perak. No. *9611* bears an unpublished specific name. These may be *T. siamense*.

The other form bears ample fronds, notable for the number of fairly uniform segments. Singapore Nos. *11043* and *15709*, from Pahang, and *7871*, from Selangor, are, as specimens of *T. obscurum*, remarkably thin and dissected. Finally, a Johore specimen collected by Holttum, without number, is exceptionally thin, and has the cell structure of *T. cupressoides*, to which species, if it came from Mauritius or Africa, I would not hesitate to refer it.

81. TRICHOMANES DENTATUM van den Bosch. Plates 45 and 46.

Trichomanes dentatum VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 182; Journ. Bot. Néerl. 1 (1861) 363.

T. cartilagineum VIEILLARD and PANCHER, ex van den Bosch, Ned. Kruid. Arch. 5 (1861) 183 and 363.

T. platyderon FOURNIER, Bull. Soc. Bot. France 16 (1869) 392.

T. Seemannes CARRUTHERS in Flora Vitiensis (1873) 345.

T. dentatum. *T. rigidum* BRACK. (non al.) in WILK. expl. exped. XVI p. 260. Fronde ovata acuminata bipinnatifida, laciniis primariis infimis

horizontalibus, sequentibus sensim minus divergentibus, supremis erectis, contiguis subaequidistantibus lanceolatis vel oblongo-lanceolatis, secundariis patulis erectisve contiguis planis, infimis laciniarum inferiorum utrinque remote subpinnatifide incisis, reliquis indivisis, cunctis margine obtuse dentatis, rhachi anguste marginata olivaceo-fusca, venulis laxiusculis parum conspicuis, cellulis forma et magnitudine valde inaequalibus irregularibusque (parvis usque magnis, varie angulosis, marginalibus minimis semi-hexaëdris), cunctis regulariter fere hyalino-reticulatis, interaneis amorphis spissiusculis e viridi olivaceis in reticuli spatia quadrangula, oblonga, rotundata dispositis, soris in laciniis secundariis axillaribus, in dente obsoleto immersis, indusio utrinque anguste marginato cylindrico parumper ventricoso, sursum in limbum patentem undulatum tubo fere 2 latiorem subito dilatato, stipitibus e rhizomate brevi polyrrhizo approximatis flexuosis apice angustissime alatis 8–10 centim. longis. Frons 8–9 centim. longa, 5–6½ lata opaca firma obscure viridis.

Ex affinitate T. elongati. . . .

Hab. Nova Caledonia (Isle of Pines) CUMING No. 7 (H. Bertol.); Ins. Societatis (Taïti), WILKES.—Van den Bosch, Ned. Kruid. Arch. 5 (1861) 182.

It will be noted that van den Bosch began with the citation of a Brackenridge fern from Tahiti, and concluded by citing a New Caledonia fern before the Tahitian. In the case of *T. cartilagineum,* he began by a nominal citation of Brackenridge, and concluded by citing Society Islands and then Fiji specimens. I believe that both are properly typified by Tahiti specimens. I regard all of them as one species; but the question of type locality is not without eventual importance, as van den Bosch may not be the last student to pay specific respect to minute differences.

As I construe it, *T. dentatum* holds the same place in Polynesia that *T. obscurum* does in Malaya, the common terrestrial species of cool, wet banks. The two species are not at all sharply distinguished, and their combination would be quite defensible. However, the typical *T. dentatum* of Tahiti is constantly distinguishable from *T. obscurum* of Java, and it will conform to usage without adding to the inevitable difficulty in drawing a line between them if the forms from New Caledonia eastward are construed as *T. dentatum* and those from Papua westward as *T. obscurum.* On the whole—that is, treating collectively the mass of material of both under observation—*T. dentatum* has less-dissected pinnules than *T. obscurum;* undivided segments or teeth with single veins are less numerous on the frond and less uniformly present on the specimens; the tendency of the tips to be curled and rolled backward is decidedly less developed, so that the herbarium specimens lie flatter; the sori are more nearly

stalked and still more conspicuously deflected from the plane of the frond; and the involucres are rather more slender, and more evidently bilabiate.

Trichomanes Seemannii Carruthers is typified by *Seemann 782*. As represented in the Gray Herbarium, this seems to me to be an unusually thin specimen of *T. dentatum*. Being thin as a whole, it has walls less than usually solid, the middle strip of lateral walls being more zigzag than usual, and the pitting of the superficial cells, in surface view, evident only near the sides of the cells. I do not believe that such distinctive character as it has is fixed.

Trichomanes ferrugineum Fournier, Bull. Soc. Bot. France 16 (1869) 392, is supposed to be distinguished by a shorter and wider involucre. The specimens I have seen so named are *T. dentatum*.

Our specimens are from New Caledonia, Vanikoro, Tanna, Fiji, Samoa, Rarotonga, and the Society Islands.

Judging by description only, *T. pumilum* van den Bosch, Ann. Sci. Nat. IV 15 (1861) 89, should be a small relative or form of *T. dentatum*.

82. **TRICHOMANES ELONGATUM** A. Cunningham. Plate 47, figs. 1 and 2.

> *Trichomanes elongatum* A. CUNNINGHAM, Comp. to Bot. Mag. 2 (1836) 368; HOOKER, Ic. Pl. pl. 701.

Fronde deltoideo-ovata acuta bipinnata, pinnis alternis lanceolatis, pinnulis basi profunde dissectis apice dilatatis inciso-lobatis lobis denticulatis, rachi stipiteque teretibus nudis, involucro oblongo compressiusculo subalato, ore bilabiato, labiis crenulatis, receptaculo elongato involucro multoties longiore.

New Zealand (Northern Island). Dark ravines in the forests of Wangaroa, etc.—1834, *A. Cunningham.*

Obs. Upon this beautiful and hitherto undescribed species, a small *Jungermannia* is occasional parasitical.—Hooker, loc. cit.

This species is very near to *T. dentatum*. They are alike, and distinct from *T. obscurum* in that the fronds are usually plane in the herbarium, or with at most moderately reflexed tips of specimens dry enough before pressing to cause other thin ferns to wilt. In New Zealand specimens the deep dissection of the base of the pinnule, and the shallow dissection toward its apex are fairly constant and diagnostic. The effect is that the undissected axis of an ovate-lanceolate pinnule is oblanceolate in *T. elongatum* and linear-elliptic in *T. dentatum*. The apices of the pinnules are also more rounded in *T. elongatum*, more acute in *T. dentatum*. The species is common

and uniform in the North Island of New Zealand. I refer to it also a larger fern from Eua (*Parks 16232*). Specimens from New South Wales and Queensland, distributed as *T. rigidum*, are neither typical nor uniform, being between *T. elongatum* and *T. dentatum;* I refer them to the former. *T. elongatum* has also been reported from New Caledonia, Fiji, and Samoa; but all so-labelled specimens I have seen from any of these (except some not in this group of species) are *T. dentatum.*

Trichomanes polyodon Colenso has been reduced to *T. elongatum* by Cheeseman.

83. TRICHOMANES LONGICOLLUM van den Bosch. Plate 47, figs. 3 to 5.

Trichomanes longicollum VAN DEN BOSCH, Ann. Sci. Nat. IV 15 (1861) 90.

Fronde subtriangulari-ovata acuminata superne pinnatifida, inferne pinnata (pinnis 2–3-pinnatifidis), laciniis superioribus erecto-patulis contiguis, inferioribus patulo-divergentibus invicem tegentibus, laciniis valde abbreviatis dentiformibus, cellulis teneris parvis mediocribusque irregularibus amoene viridibus acute crenulatis regulariter poroso-punctatis, soris in laciniis secundariis axillaribus longissime exsertis recurvis anguste cylindricis longe deorsum angustatis. Rhizoma breve adscendens radiculosum nigro-fusco-hirsutum stipites emittens fasciculatos (8 centim. longos) validos olivaceos teretiusculos; frons 15 centim. longa, basi 9, medio 6,5 lata rigidiuscula e flavo-viridi olivacea.

Hab. In sylvis montium, Balade [New Caledonia], VIEILLARD, herb. n. 1662.—Van den Bosch, loc. cit.

The fronds are exceptionally thin and herbaceous for this group. Both pinnæ and pinnules are congested and, therefore, without being wide, are conspicuously imbricate. The pinnules are not deeply dissected unless at the base. It thus resembles *T. elongatum,* from which it is clearly distinguished solely by the stalked sori. An examination of several collections shows uniformly a double pitting or areolation of the walls, but a similar structure is occasionally found in *T. dentatum* and *T. obscurum.*

Trichomanes longicollum seems not to be common in New Caledonia, and is unknown elsewhere.

84. TRICHOMANES EXTRAVAGANS Copeland sp. nov. Plate 48.

T. gregis T. rigidi soris exaltatis insigne, stipitibus dense caespitosis, 6 ad 10 cm altis, teretibus setulis deciduis aspersis; fronde usque ad 10 cm alta et 8 cm lata, deltoideo-ovata, subcoriacea, atroviride, tripinnatifida, rhachi deorsum tereta, apicem

versus alata; pinnis imbricatis, infimis oppositis 4 cm longis, 2.5 cm latis, rhachi basi tereta setosa, alibi alata, pinnulis paucis, oblongis, ad alam latam pinnatifidis, segmentis paucis angustis, ad basin acroscopicam soriferis; pinnis superioribus pinnatifidis segmentis basi dilatatis acroscopice soriferis; ramo sorifero segmenti attenuata, deinde filiforme, ca. 3 mm longo, recto vel reflexo; involucro 1 mm longo, subventricoso vel elongato cyathiforme obsolete alato, ore truncato, receptaculo duplo longiore sed fragile.

LUZON, Tayabas Province, Mount Binuang, *Bur. Sci. 28465 Ramos and Edaño.*

A species of bizarre appearance because of the numerous long-stalked sori; remarkable also for the few pinnules and segments and the dilation of their bases.

85. **TRICHOMANES TERETICAULUM Ching.**

T. tereticaulum CHING, Sinensia 1 (1929) 2; HU and CHING, Ic. Fil. Sinic. 5, pl. 3.

Eutrichomanes, subsect. Ptilophyllum, v. A. v. R. in Handb. Malay. Ferns, p. 83 (1908). Rhizome naked or nearly so, very short, interwoven in dense wiry fibrous roots; stipes densely caespitose-fasciculate, wiry, rigid, teret, not winged or only narrowly winged towards the apex, 4–6 cm long or longer, naked. Fronds glabrous, subdeltoid to linear-oblong, 4–6 cm long, 2–2.5 cm broad, 3-pinnatifid, rachis narrowly winged throughout; pinnae 3–5 on each side, remote erect, patent, oblong-ovate, 1–2 cm. long, the upper ones gradually shortened; pinnules 2–4, entire or 2–3 pinnatifid into small linear, entire, rounded segments; texture thin-herbaceous, translucent, dull-green; veins distinct, 1 to each segment, spurious veinlets wanting. Sori terminal on ultimate segments, mostly immersed, 2–3 to each pinna, indusium short funnel-shaped slightly dilated, obscurely undulate at mouth, not bifid, receptacle long-exserted, stout, dark-brown. . . .

Hab. Seh-feng Dar Shan, S. Kwangsi, near the border of Tonkin. . . . about 1800 ft. elevation. (*R. C. Ching*, No. 8239.)—Ching, loc. cit.

A stunted representative of *T. obscurum,* not widely separated from the small plants already known from the northern part of the range of that species. The specimen in the herbarium of the University of California conforms perfectly to the description, including stipes 6 cm long, but no frond quite reaching that length; but the longest fronds present have much shorter stipes, and the long stipes bear only the old bases of fronds presumably larger. I suspect, therefore, that in full development it may be indistinguishable from the small Peninsular plants already discussed; and that, if it be specifically distinct

from *T. obscurum* it is *T. siamense.* It has the zigzag, toothed lateral walls of the small Peninsular specimens.

The reference to *Ptilophyllum* v. A. v. R. is correct, but that "subsection" might fitly occupy by itself a chamber of horrors in the museum of taxonomic botany. It included *T. pallidum, T. humile, T. bipunctatum, T. auriculatum, T. pyxidiferum, T. maximum,* and *T. grande,* representing as many properly distinct groups; but it did not include any relative of *T. tereticaulum,* nor did it have one species in common with the *Ptilophyllum* of van den Bosch or Prantl, from one or both of whom the name must have been pirated. Van den Bosch first used it for a section name, in unwarranted substitution for *Achomanes* and *Pseudachomanes* of Presl. Prantl endowed it, as a genus, with species, deliberately including the older *Feea* but discarding the name "weil letzterer sich nur auf sehr wenige Arten bezog," and in spite of the fact that *Ptilophyllum* was preoccupied. Less intentionally, presumably, he included the type species of *Trichomanes* itself.

86. TRICHOMANES CUPRESSOIDES Desvaux. Plate 49.

T. cupressoides DESVAUX, Prod. de la Fam. des Foug. (1827) 330.
T. obscurum var. *pectinatum* METTENIUS, in Kuhn, Fil. Afric. 35.

Frondibus elongato-deltoideis, decurrentè tripinnatifidis; pinnellis adpressis, nervosis apici dentatis: infimis basi bicuspidato-subulatis, columellis plerisque inclusis; rachibus subpruinoso-pilosis: partialibus subnudis; stipite tereti.

Habitat in insulis Séchelles. Frondes caespitosae.—Desvaux, loc. cit.

As is true of many of the earlier descriptions, this might apply to any species in its group. I interpret the species by a specimen collected in Usambara, *Holst 4269, U. S. Nat. Herb. 807579,* determined by Hieronymus as *T. obscurum* Bl. var. *pectinata* Mett. This name was published without description, as a reduction to *T. obscurum* of *T. cupressoides;* it is a reasonable assumption that Mettenius and Hieronymus knew their plants.

The frond is deltoid-ovate, 15 cm long, on a stipe of the same length. The pinnules are oblong, obtuse, obliquely and symmetrically pinnatifid almost to the costa, with the larger segments narrowly toothed. The older, smaller fronds, produced when the plant was younger, are less dissected, falling within the range of *T. obscurum;* but they are more delicate in texture, and no frond of *T. obscurum* is as much or as regularly dissected as are the three well developed fronds of this specimen. Oc-

casional fronds of *T. obscurum,* sometimes mistaken for *T. setaceum,* bear even longer and narrower segments, but the dissection is not symmetrical, and leaves a larger intact medial lamina. The walls of *T. cupressoides* are thinner, and less largely composed of cellulose (in distinction to pits), wherefore the solid element of the lateral walls, as seen in exact focus, appears more wavy. The rachises are broadly sulcate, and the stipes of the larger fronds are deeply so. The tendency of the tips to curl is less evident than in *T. obscurum.* The receptacle projects by less than the length of the short involucre.

The species concept of Hooker and Mettenius would justify identification of this fern as *T. rigidum* and *T. obscurum.* That of to-day does not. The dissection and the sulcate axes seem easily diagnostic. Judging by this specimen (possibly because a single plant is in hand), it seems decidedly more distinct from *T. obscurum* than does *T. dentatum.*

87. **TRICHOMANES MANDIOCCANUM Raddi.**

Trichomanes mandioccanum RADDI Pl. Bras. 1 (1825) 64, t. 79, f. 2.

Without entire confidence, I accept this identification of *Warnoth 334, U. S. Nat. Herb. 554551,* from Amani, German East Africa. The identity with specimens from near Rio de Janeiro is approximate, the latter having more conspicuously wavy lateral walls of laminar cells, but those of this specimen being more wavy than those of any Oriental species of the group. The fact is neither overlooked nor explained that Müller, Bot. Zeitung 12 (1854) 750, described these walls as straight. The dissection of the frond is as fine as in *T. cupressoides,* but less regular. The segments are as badly curled as is common in *T. obscurum,* but in this case, the fronds being much thinner, it is probably due to the pressing of a wilted specimen. *Buchanan 522,* from Natal, is possibly the same species.

In view of uncertainty of identification, a full description of this Brazilian species may be omitted here.

88. **TRICHOMANES STYLOSUM Poiret. Plate 51, figs. 3 to 5.**

Trichomanes stylosum POIRET, in Lam. Enc. 8 (1808) 82.

Trichomanes frondibus subtripinnatis, pinnis alternis, pinnulis decurrentibus; laciniis linearibus, subintegris, obtusis; fructificationibus terminalibus, solitariis, longè stylatis.

Ses souches sont épaisses, noirâtres: il s'en élève des feuilles pétiolées, droites, presque trois fois ailées, longues de dix à quinze pouces, acuminées, d'un vert-sombre, point transparentes, très-glabres, composées de folioles

alternes, lancéolées; de pinnules alternes, légèrement décurrentes, presque pinnatifides ou divisées en découpures presque simples, entières, courtes, linéaires, obtuses à leur sommet, quelquefois un peu échancrées; leur fructification située au sommet des découpures inférieures, sous la forme d'un petit godet en entonnoir, d'un brun-foncé, traversé par une columelle en forme de style capillaire, très-saillant en dehors, long de deux à trois lignes, caduc. Les pétioles sont d'un brun-foncé, presque cylindriques, glabres, souples & durs.

Cette espèce a été recueillie à l'île de Madagascar par M. du Petit-Thouars.—Poiret, loc. cit.

I have no authentic material of any Madagascar species of this group. In the United States National Herbarium are sheets *51118* and *51119,* collected by Dr. P. B. Ayres in 1862, determined at Kew as *T. rigidum; 593169,* collected by Mrs. N. Pike in 1869, undetermined; *817018 C. E. Bewsher* in 1888, from Kew; and *817019,* from Berlin, without data except "Mauritius," the last two as *T. rigidum.* All are one species, and it is the species described by Müller, Bot. Zeit. 12 (1864) 750, as *T. achilleaefolium* Willd. I assume that he was correct, and that van den Bosch, Synopsis 32, and Christensen have correctly construed this as *T. stylosum* Poir. It is obviously impossible to distinguish the components of Hooker's *T. rigidum* by diagnoses of the time of Poiret, Bory, Willdenow, and Desvaux.

This species has more slender and less coriaceous fronds than *T. obscurum.* An ordinary frond is 20 by 6 cm; the largest seen, 25 by 10 cm. They are somewhat narrowed at the base; stipe and rachis are comparatively naked; the rachis of most fronds is narrowly winged quite to the base; and the structure of the walls of the laminar cells is diagnostically different, the pits being much smaller and occupying a very minor part of the entire space of the walls.

89. **TRICHOMANES BATRACHOGLOSSUM** Copeland sp. nov. Plate 50; Plate 51, figs. 1 and 2.

T. gregis T. rigidi, stipitibus fasciculatis, 15 cm altis, basi setis obscuris 1 ad 1.5 mm longis praeditis, sursum glabratis leviter sulcatis; fronde 15 cm alta anguste deltoidea, rhachi anguste alata, late sulcata, superne costisque pinnarum setosis, pinnis haud imbricatis inferioribus oppositis; pinnis infimis usque ad 5 cm longis, 2 cm latis, basiscopice auctis, bipinnatifidis, costis distinctius alatis; pinnis sequentibus infimis 3 cm longis, 12 mm latis, obtusis, ad alam conspicuam costae pinnatifidis, segmentis majoribus 2 mm latis, angulo acuto incisis, lamina coriacea atroviride, parietibus lateralibus cellularum in foco

exacto tenuibus late undulatis, soris multis, parvis, sessilibus basi vix immersis, inflexis, involucro 1 mm longo, cylindrico, angustissime alato, ore truncato vel saepius minute dilatato, receptaculo duplo vel triplo longiore, curvato.

LIBERIA, *O. F. Cook 392*, type *U. S. Nat. Herb. 946305.*

A member of the group of *T. rigidum,* as shown by the fascicled stipes, pubescence, texture, and sori; very distinct within the group, because of the nonterete, winged axes, small (basal excepted) pinnæ, and sori bent above the plane of the frond. The structure of the walls suggests that of *T. mandioccanum.*

13. CEPHALOMANES; THE GROUP OF TRICHOMANES JAVANICUM

Terrestrial; rhizome ascending, in age becoming an erect caudex, supported by many stout, dark roots; fronds fasciculate, mostly lanceolate, simply pinnate (rarely only pinnatifid), dark, harsh in texture, with coarse veins and large laminar cells, the walls thin in proportion to the size of the cells, and the contents dark; involucres cylindrical (rarely shortened to obconic), very firm; receptacle commonly long-exserted, coarse, sometimes enlarged at the tip. An exceptionally large and globose receptacle-tip, as observed by Presl, was responsible for his generic name, *Cephalomanes.*

The caespitose, nondeltoid, harsh, dark, simply pinnate fronds make this an exceptionally easily recognized group of species. It ranges from Malaya to Madagascar, the Himalayas, and the Marquesas. *Trichomanes javanicum* occupies the middle area, and is replaced, as a very common fern, by *T. asplenioides* in the Philippines, and by *T. boryanum* in Polynesia. *Trichomanes atrovirens* ranges from Luzon to Papua, and may prove to be the common species in the latter. The other species are comparatively local.

A notable characteristic of this group is the tendency to produce fruit while still in a stage of growth well short of the full maturity in which the characteristics of the several species reach their full development. The great majority of the individuals which reach a fruiting stage evidently never attain a more perfect maturity. The semiadult plants, of whatever species, have short stipes, small fronds, sori aggregated near the apex, and in general shorter involucres, as compared with really mature individuals of the same species; and the several species, as represented by these semiadult plants, are far less distinct than when known by older and perfectly developed specimens.

Key to the species.

Fronds pinnate at base only, if at all.................................... 101. *T. crassum.*
Fronds pinnate.
  Pinnæ broadly cordate.. 100. *T. madagascariense.*
  Pinnæ not cordate.
    Sori borne in a terminal spike or panicle.
      Involucres truncate.
        Rachis wingless, sori large..................... 92. *T. sumatranum.*
        Rachis narrowly winged.................................. 96. *T. Kingii.*
      Mouth of involucre somewhat dilated............ 97. *T. acrosorum.*
    Sori on normal pinnæ, mouth ciliate..................... 99. *T. Foersteri.*
    Sori on normal pinnæ, mouth not ciliate.
      Sori on acroscopic margin of pinnæ, and salient beyond it.
        Mouth of involucre truncate................ 90. *T. javanicum.*
        Mouth slightly dilated, pinnæ very imbricate.
          Stipe short, pinnæ lacerate................ 94. *T. atrovirens.*
          Stipe long, pinnæ shallowly cut....95. *T. densinervium.*
        Mouth conspicuously dilated.................... 98. *T. boryanum.*
      Sori in notches on acroscopic margin.... 91. *T. singaporianum.*
      Sori tending to be apical on the pinnæ.
        Sori large, restricted to apex of frond.
          92. *T. sumatranum.*
        Sori of mature plants not confined to apex.
          93. *T. asplenioides.*

90. TRICHOMANES JAVANICUM Blume. Plate 52, fig. 1.

T. javanicum BLUME, Enumeratio (1828) 224.
Cephalomanes javanicum VAN DEN BOSCH, Hymen. Javan. 30, pl. 22.
Cephalomanes Zollingeri VAN DEN BOSCH, Hymen. Javan. 31, pl. 23.
Cephalomanes rhomboideum VAN DEN BOSCH, Hymen. Javan. 33, pl. 24, but not *Trichomanes rhomboideum* J. Smith.

T. fronde pinnata lanceolata acuminata glabra, pinnis subsessilibus cuneato-oblongis obtusis serratis vel inciso-serratis striatis pellucidis glabris, stipite rachique setosis.

OBS. Affine *Trichomani heterophyllo,* Humb.

Crescit in umbrosis humidis Javae interioris.

Var. B. Serraturis setaceis.

Crescit in sylvis insulae Nusae Kambang.—Blume, loc. cit.

This species properly typifies the group, although *T. atrovirens* is technically the type of Presl's genus *Cephalomanes.*

Trichomanes javanicum is a very common fern in Java, Sumatra, and the Peninsula, and varies as common ferns are wont to do. A few specimens might well seem to represent distinct species, especially if chosen to illustrate its range of forms; and it is worthy of note that the two van den Bosch species

which I do not maintain were both based on Zollinger specimens regarded as *T. javanicum* by the collector. *Trichomanes Zollingeri* is a half-grown plant, with the sori restricted to the reduced pinnæ near the apex. It is represented by a majority of the specimens, in herbaria and in the field. *Cephalomanes rhomboideum* is the form with most cut margin, particularly with prolonged, curved prongs from the basiscopic margin. It has not the very numerous, short, widely imbricate, dark brownish pinnæ of the Philippine plant, *T. atrovirens*, with which van den Bosch confused it.

Trichomanes javanicum, well developed, has fronds 20 to 25 cm long, on stipes 8 to 12 cm tall, the sori borne on the acroscopic margin of the pinnæ, in full fruit extending to, but not usually around, the apex. The indusium is commonly 2 mm long, tubular, somewhat immersed, or slightly winged at the base, or sessile, ribbed rather than winged at the sides, truncate at the apex, sometimes undulate or slightly notched at the sides. Over a wide area, it occupies the place taken in the Philippines by *T. asplenioides*, and in Polynesia by *T. boryanum*. It is distinguished from the latter by the truncate involucre; from the former, by the position of the sori, and less certainly by more numerous and narrower pinnæ. The other species of the group are comparatively local and rare.

Java to the Himalayas and Papua.

Several small Bornean specimens—*Clemens 9478* and *Ramos 1268* from Sandakan; *Bur. Sci. 932 native collector*, from Sarawak—have winged or marginate involucres with crenate, slightly dilate mouths. The crenation is less conspicuous on the largest such specimen, *Boden-Kloss 19170*. These may represent a distinct local species, but I leave them in *T. javanicum* until surer of its limits.

91. TRICHOMANES SINGAPORIANUM v. A. van Rosenburgh. Plate 52, fig. 5

T. singaporianum v. A. VAN ROSENBURGH, Bull. Jard. Buit. II 20 (1915) 25.

Cephalomanes singaporianum VAN DEN BOSCH, Synopsis (1859) 11.

T. javanicum HOOKER and GREVILLE, Ic. Fil. pl. 240, non Blume.

T. Christii ROSENST., Bull. Jard. Buit. II 2 (1911) 27, non Copel.

T. Rosenstockii V. A. VAN ROSENBURGH, Bull. Jard. Buit. II 7 (1912) 27.

T. borneense V. A. VAN ROSENBURGH, Bull. Jard. Buit. II 20 (1915) 25.

Fronde pinnata lato-lanceolata, pinnis subsessilibus oblongis basi oblique cuneatis obtusis inciso-subpinnatifidis (praecipue margine superiore)

nervosis glabris, stipite rachique marginatis setosis, involucris in sinubus laciniarum superiorum plerumque solitariis.

Hab. . . . In Insula Singapore. *N. Wallich, M.D.*—Hooker and Greville, loc. cit.

T. singaporianum . . . has the pinnae incised towards the base, especially on the upper side, less so on the lower side, with the lobules subtriangular, narrowed toward the apex, the sori in the sinuses of the lobules, the indusia immersed ca $\frac{1}{2}$-way down, more or less conspicuously urceolate and narrowed at the mouth.—V. A. van Rosenburgh, loc. cit.

Neither van den Bosch nor van Alderwerelt knew this plant except through the eyes of Hooker and Greville; however, they named a plant, and therein had better luck than sometimes falls to those who base names on pictures. The Wallich specimen was immature, as shown by its size and imperfect dissection. Well grown fronds reach a length of 20 cm, although 15 cm is commoner. The pinnæ, except near their apices, are regularly lobate-pinnatifid halfway to the costa on the acroscopic side, the lobes usually narrowly or broadly oblong, and rounded or truncate. The involucres are sessile or slightly immersed, and only 1 mm long, falling far short of the general outline of the frond.

There are ten sheets in the Singapore Herbarium, from Singapore, Johore, Selangor, and Malacca; the plant is also in Borneo.

Van Alderwerelt's description of *T. borneense* is perfectly applicable to well-developed *T. singaporianum.*

92. TRICHOMANES SUMATRANUM v. A. van Rosenburgh. Plate 53, fig. 4.
53, fig. 4.

Trichomanes (*Cephalomanes*) *sumatranum* v. A. VAN ROSENBURGH, Bull. Dept. Agr. Ind. Néerl. No. 18 (1908) 4.

T. javanico et asplenioideo affine. Pinnae margine acroscopico lobatae, apice dentatae, lobis apice dentatis, inferioribus (1–3) ± elongatis et auriculiformibus, lobis inferioribus pinnarum inferiorum liberis et plerumque petiolatis; pinnae superiores apicem frondis versus sensim reductae, summae valde contractae, petioliformes, anguste marginatae. Sori apices pinnarum superiorum occupantes, in pinnis reductis solitarii, in pinnis caeteris 1 vel plures, indusio marginato, limbo erecto, truncato, leviter concavo, alis in dentes laterales minutos excurrentibus.

Sumatra (Burck).—V. A. van Rosenburgh, loc. cit.

As described, this species would have bipinnate fronds, but I am satisfied that such an appearance, when it occurs, is due to damage or dissolution. The pinnæ of well developed fronds are broad at the base, usually narrowing thence to the apex. The basiscopic margin is likely to bear a few short, sharp, appressed teeth, and the upper margin to have a few deep incisions; still the pinnæ are exceptionally entire, for this group. The sori are

grouped near the apex, even in the best-developed specimens seen, and the lamina is so contracted from their bases that they appear distinctly stalked. Their position is distal, as in *T. asplenioides*, in distinction to acropetal, as in *T. javanicum;* however, the affinity to the latter species is probably the closer. The involucre is large, often more than 2 mm long, and perfectly truncate.

SUMATRA, *Bartlett 6648a, 7091, 7093; Ramat si Toroes 174; Hancock 43; Yates 1136.* SIBERUT ISLAND, *Boden-Kloss 14600.* BORNEO, *Moulton 205,* of 1914; *Bur. Sci. 2948 native collector.* ANNAM, *Clemens 3015.* The Borneo and Annam collections are not quite typical.

93. TRICHOMANES ASPLENIOIDES Presl. Plate 52, fig. 2; Plate 55, fig. 1.

T. asplenioides PRESL, Hymenophyllaceae (1843) 129; KUNZE, Farnkräuter 218, pl. 89.

T. fronde lineari-lanceolata elongata glabra pinnata, pinnis alternis oppositisque sessilibus oblongis obtusis crenulatis inaequilateralis inferne angustioribus acutis superne latioribus truncatis auriculatis, fructiferis irregulariter fissis aut laceris, venis creberrimis furcatis venulisque crassiusculis, rachi inferne hinc canaliculata hinc tereti, stipite tereti basi hirsuto, rhizomate brevi oblique repente.

Cuming pl. exs. philipp. n. 184.—Presl, loc. cit.

T. fronde coriacea, rigida, . . . parte superiori sorophora; pinnis . . . trapezio-oblongis, curvulis, apice subdilatato obtusis, denticulatis, . . . fertilibus apice s. margine superiori inciso-laceris; involucris cyathiformibus, ore elabiato repandis, semiemersis; . . . rhachi marginata, hirsuta; stipite brevissimo, flexuoso. . . .

Nur an dem oberen Drittheile des Wedels werden die Fiedern fruchttragend, oft nur an der Spitze. Solche fertile Fiedern erscheinen am Vorderrande, bisweilen auch am vorderen Theile des Oberrandes tief, fast bis zur Mitte eingeschnitten und auf den so gebildeten linienförmigen Zipfeln sind die Früchte, in der Zahl von 3–7 an jeder Fieder, befindlich.—Kunze, loc. cit.

Kunze observed also that Cuming's specimens were overripe, which is true of the fronds but not of the plants, which seem to have been immature. This is shown by the weakly developed rhizome, the short stipes, the size of the plants; and the degree of restriction of the sori to the apex of the frond. The sori are always most abundant toward the apex, but may be present at least two-thirds of the way to the base. The fronds of well grown plants are commonly up to 20 cm long, 4 cm wide, on stipes 8 cm long. The longest frond I have measured is 33 cm long, the stipe 15 cm. Fully half of the collections of this species are immature, as plants, with weakly developed caudices, stipes more or less 2 cm long, fronds not over 10 cm, and with

sori congested near the apex, often on decidedly reduced pinnæ. These ill-developed specimens are doubtfully if at all distinguishable from *T. javanicum* in the corresponding stages. I assign them to *T. asplenioides* in the Philippines, to *T. javanicum* in Java, the Peninsula, etc., because well-developed individuals from the same regions belong uniformly to one or the other.

Large fronds of *T. asplenioides* are usually narrower than those of *T. javanicum,* with the pinnæ relatively broad and entire. The conspicuous and dependable distinction is in the position of the sori on the pinnæ, tending to occupy the apex in the former, the acroscopic margin in the latter.

Trichomanes asplenioides is the very common representative of the group in the Philippines, common from the Batanes to Basilan, wanting perhaps in Palawan. As there are some eighty collections, I may abstain from enumerating them; all are distributed as *T. javanicum,* to which I refer no Philippine specimen. So common a plant naturally varies, but in this case rarely or never so far that a well-grown specimen could be mistaken for another species; the few doubtful cases will be mentioned in the discussion of *T. atrovirens.*

Beyond the Philippines, there is an Amboina specimen, *Robinson 1964,* with the fructification of *T. asplenioides,* but narrower and more numerous pinnæ than typical plants bear. Until an opportunity to study Celebes material may show the range in that direction, I refer this to *T. asplenioides,* with doubt. *Trichomanes javanicum* is likewise variable where it is common. Rare individuals in such places bear distal sori—examples are *Henderson 18765* and a collection by Burkill in Pahang, and *Achmad 414,* from Simalur Island, near Sumatra; because they are isolated cases, and like *T. javanicum* in other respects, I regard them as aberrant individuals of that species. Finally, there are Bornean collections with some tendency to distal fructification. They are small plants, with short petioles and mostly apical sori, and I have already noted the lack of distinctive character by such plants. Every well developed Bornean specimen I have seen is clearly *T. javanicum.* Still, Borneo is ill known, and *T. asplenioides* may be there; or the two may blend there. If they do, I would still consider it convenient to treat as specifically distinct in the Philippines a plant which, as thoroughly collected as this has been, maintains so well its local distinctive character.

94. TRICHOMANES ATROVIRENS Kunze. Plate 52, fig. 3; Plate 55, fig. 2.

T. atrovirens KUNZE, Bot. Zeit. 5 (1847) 371.

Cephalomanes atrovirens PRESL, Hymen. (1843) 110, pl. 5.

Trichomanes rhomboideum J. SMITH in Hooker's Journ. Bot. 3 (1841) 417, nomen, not *Cephalomanes rhomboideum* van den Bosch, except as to the name-bringing synonym.

The first description of this species is incorporated in that of Presl's genus *Cephalomanes,* of which this is the type species.

Venae pinnatim exorientes, creberrimae, prominulae, uni-bifurcatae, venulisque sterilibus apice obtuso liberae. Sorus in dentibus frondis obliteratis terminalis, pedicellatus. Indusium cylindraceum, limbo patente integro. Receptaculum indusio dimidio duplove longius, rectum, rigidulum, cylindricum, apice in globum incrassatum, basi capsuliferum. Capsulae sessiles, lenticulares.

Rhizoma . . . stipitibus aut illorum residuis aggregatis radicibusque duas trientes lineae crassis filiformibus flexuosis rigidis tam arcte obtectum, ut vix aut non conspicitur. Stipites pollicares, semilinea paululum crassiores, teretes, paleis piliformibus fuscis flexuosis usque sesquilineam longis adspersi, demum glabrati. . . . Frons (in strictissimo sensu) sex-septempollicaris, pollicem lata aut angustior, arcuato-subfalcata, exsiccata nigricans, lineari-lanceolata, acuta, basi angustata, pinnata. Pinnae (exceptis infimis paullo distantibus) contiguae, alternae, petiolulo vix semilineali insidentes, oblongae, rotundato-obtusae, inaequilaterae, latere superiori latiore basi truncato . . . latere inferiore duplo angustiore laciniato basi acuto vel acutissimo . . . laciniis sinu lato interceptis anguste linearibus (exsiccatione apparenter setaceis) acutis simplicibus aut subinde bilobis, lobis divergentibus. . . . Sori solummodo in margine superiori pinnarum . . . pedicello brevissimo quamquam bene conspicuo insidentes. Indusium linea paululum longius, cylindraceum, basi acutum, limbo brevissimo patente integro. . . .

. . . insulas Philippinas inhabitat . . . Cuming . . . numero 169 . . .—Presl, loc. cit.

The "more or less thickened" tip of the receptacle is not always present, and I have never seen it as large and perfectly spherical as Presl figured; and similarly enlarged tips are sometimes evident on other species of the group. The slightly dilated mouth of the involucre is almost always present, but not invariably. The margin is always laciniate dentate, with a few notably long, lashlike laciniæ on the basiscopic margin, sometimes deflexed, but, when longest, bent upward across the pinna; but such margins are occasionally found, only less accentuated, on other species, especially on the form of *T. javanicum* which van den Bosch identified with the Philippine plant.

While none of these more minute distinctions is absolutely distinctive, *T. atrovirens* is readily recognizable by its narrow,

very compact fronds, with very numerous small, imbricate pinnæ, dark color, and thin texture. The stipes are characteristically short, commonly 1 to 3 cm long, with well developed fronds 20 cm long and 2.5 cm wide.

Although far from as common as *T. asplenioides*, this is not a rare species in the Philippines, occurring the length of the Archipelago. Collections are: *Cuming 169*, in most herbaria (in my own, this number is *T. asplenioides*); *Weber 1544*, Cagayan Province; *For. Bur. 2397 Borden, Williams 148, Merrill 3121, Copeland 206, Elmer 6880*, all from Mount Mariveles, Bataan Province; *Copeland s. n.*, Cavite; *Bur. Sci. 1810 Ramos*, and *Bur. Sci. 48848 Edaño*, Rizal Province; *Williams 2039* and *Elmer s. n.*, Laguna Province; *Bur. Sci. 20696 Escritor*, Tayabas Province; *Bur. Sci. 48365 Ramos & Edaño*, Alabat Island; *Elmer 12484*, Sibuyan; *Bur. Sci. 17606 Ramos, Bur. Sci. 24772 Edaño*, Samar; *Bur. Sci. 35372 Martelino and Edaño, Bur. Sci. 42357 Edaño*, Capiz Province; *Bur. Sci. 41742 Edaño*, Leyte; *Bur. Sci. 42980 Ramos*, Bohol; *Bur. Sci. 35150 Ramos and Pascasio*, Dinagat Island; *Wenzel s. n.* Surigao. Specimens combining the characters of *T. atrovirens* and *T. asplenioides* are *Copeland 207* and *Topping 810*, from Mount Mariveles, and *Wenzel 173*; they may be hybrids.

Bur. Sci. 578 Foxworthy, from Palawan, has the color, the congested, stipitulate pinnæ, and long basal hairs of *T. atrovirens*, but has comparatively entire margins and long stipes; although a large plant, it bears few sori. It may be a distinct species; or is possibly to be referred to *T. javanicum*.

NEW GUINEA, *Bavaler 210*, in Bureau of Science herbarium; *Lauterbach 521*, in the Singapore herbarium; *Werner 52; Brass 677, 1482*. QUEENSLAND, as attested by the figure of "*Trichomanes javanicum*" in Bailey's Lithograms of the Ferns of Queensland, pl. 24, left.

Trichomanes Ledermanni Brause, Bot. Jahrb. 56 (1920) 35, known to me by description only, seems to be a small *T. atrovirens*. The latter is said to be distinguished by stronger and larger, longer-petioled fronds, with irregularly toothed acroscopic margins and more numerous bristlelike teeth on the basiscopic margins, more closely placed nerves, and cylindrical sori with shorter receptacles. But, like all of the group it can be fertile while far from fully developed in size; it is characterized by short stipes; may be perfectly regularly dentate on the acroscopic margin, and has usually few bristles (in distinc-

tion to *Cephalomanes rhomboideum* as figured by van den Bosch). Brause may have had van den Bosch's plant in mind.

Trichomanes maluense Brause, Bot. Jahrb. 56 (1920) 36, also unknown to me save by description, is another small fern of the same group. The fronds, up to 10 cm long, are fertile through two-thirds of their length, and with as many as nine sori to the pinna or segment. They are described as pinnatifid, and the divisions are called segments, which, if accurate, distinguishes the species from others; but later in the diagnosis we find "rachibus teretibus, glabris, angustissime alatis," seeming to apply to a pinnate frond.

95. TRICHOMANES DENSINERVIUM Copeland. Plate 53, fig. 1.

Trichomanes densinervium COPELAND, Philip. Journ. Sci. 6 (1911) Bot. 71.

Cephalomanes stipite valido vix 10 cm alto, fronde 18 cm alta, vix 4 cm lata, sursum sensim angustata, pinnis proximis valde imbricatis, infimis haud remotis, obliquis, apice rotundatis, ciliatis, venis angulo acuto orientibus, proximis, crassis, furcatis et inferioribus acroscopicis iterum furcatis; soris partem superiorem frondis occupantibus, acroscopicis, ad pinnam quamquam usque ad 8, uniformibus, indusiis compresso-infundibuliformibus, truncatis, limbo paullo dilatato vel interdum recto, receptaculo exserto.

[New Guinea, *King*] *No. 150.*

Differs evidently from *T. javanicum* Bl., *T. atrovirens* Kze., and *T. Zollingeri* v. d. B. in the coarse veins, which stand at a much more acute angle to the costa. The frond is also conspicuously more compact and the pinnae more rounded.—Copeland, loc. cit.

The congested, broadly imbricate pinnæ, the position of the sori on the pinnæ, and the shape of the involucre, are all as in *T. atrovirens,* which I recognize as a New Guinea species. *Trichomanes densinervium* is distinguished by much more coriaceous and less cut pinnæ, long stipe, and the aggregation of the sori toward the apex of the frond. It is known only by the type collection.

96. TRICHOMANES KINGII Copeland. Plate 53, fig. 2.

Trichomanes (Cephalomanes) Kingii COPELAND, Philip. Journ. Sci. 6 (1911) Bot. 72.

Rhachi anguste alata, glabra; pinnis laceratis; paniculo breve; indusio conico, vix 2 mm alto, 1 mm vel ultra lato, limbo haud dilatato; aliter praecedenti [T. acrosoro] simile.—Copeland, loc. cit.

New Guinea, Lakekamu, collected by Copland King.

This species was described from a single old frond, too worn to be really fit for description. It is impossible to say how completely its age may have been responsible for the lacera-

tion of the pinnæ. A winged rachis, however, would disappear, if affected at all by age. This, and the stalked sori, seem to distinguish *T. Kingii* from the many imperfectly developed forms of *T. javanicum.*

97. **TRICHOMANES ACROSORUM** Copeland. Plate 53, fig. 3.

Trichomanes (*Cephalomanes*) *acrosorum* COPELAND, Philip. Journ. Sci. 6 (1911) Bot. 72.

Stipitibus confertissimis 1–2 cm altis; fronde 6–10 cm alta, 1.5–2 cm lata, rhachi pilosa glabrescente; pinnis 10–12 mm longis, basi cuneatis, apice rotundatis, dentatis et interdum partitis, venatione sublaxa; pinnis supremis fertilibus, 1–3-soratis, lamina carentibus, indusio 2.5–3 mm longo, infra limbus plus minus dilatatum vix 1 mm crasso; receptaculo usque ad 7 mm exserto.

[New Guinea: *King*] *No. 352*, Lakekamu.

The racemose or narrowly paniculate sori make this very distinct from any species hitherto known.—Copeland, loc. cit.

Known only by the type collection. The restriction of the sori to the apical region is characteristic of small—that is, immature—individuals of the larger species, notably of *T. javanicum* and *T. asplenioides.* But so distinctly spikelike a fertile region, with such elimination of the lamina of the fertile pinnæ, does not occur in any other species, even in *T. sumatranum;* and this species has very different involucres.

98. **TRICHOMANES BORYANUM** Kunze. Plate 52, fig. 4.

T. boryanum KUNZE, Farnkräuter (1847) 237, pl. 97.

Cephalomanes australicum VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 139; Journ. Bot. Néerl. 1 (1861) 341.

Cephalomanes Wilkesii VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 140; Journ. Bot. Néerl. 1 (1861) 345.

T. fronde tenui, subcoriacea, pellucidula, glabra, curvato-lanceolata, obtusiuscula, pinnata, dimidio superiore sorophora; pinnis breviter petiolatis, approximatis, trapezio-oblongis, subfalcatis, obtusis, basi sursum truncata, deorsum cuneata in petiolum et superne ad rhachin decurrentibus, sterilibus dentatis, subincisis; fertilibus in medio marginis superioris profunde inciso-laciniatis, laciniis sorophoris; involucris poculiformibus, marginatis, ore dilatato, subbilabiato repandis; receptaculo cylindrico, exserto; rhachi marginata, apice subalata petiolisque sparsim setoso-paleaceis; stipite brevi, versus basin setoso-paleaceo; rhizomate erecto, brevi, caespitoso, radicoso.

Trichomanes alatum Bory. . . . (non Swartz).

Diese Art wurde bis jetzt nur auf Ualan. . . . einer der Karolinien, beobachtet.—Kunze, loc. cit.

There are one or two derived synonyms for each original synonym noted.

The essential distinction from all Malayan species is provided by the flaring mouth of the involucre, which is not at all bilabiate, nor so figured by Kunze. The involucre may be slightly immersed at the base, or sessile, or distinctly stalked. It can usually be seen to be slightly winged, even if stalked. Kunze described and, in the enlargement, figured it as widened gradually from the bottom; if this is accurate and constant, his species is distinct from that of Fiji, etc., which is then *T. australicum;* but I mistrust this feature, because it is not so drawn in Kunze's natural-size figure, and specimens from Yap, *Volkens 161, 362,* have them widened immediately above the base to a tube, which then widens but little up to the dilated mouth. Sori are usually wanting on the lower half of the frond. They are borne on the acroscopic side, not on the tip, of each fertile pinna. Where they stand, the lamina is cut back fully halfway to the costa, as correctly shown by Kunze in his "Habitus" sketch, but not in his enlargement—another reason for my mistrust of the latter.

The range in size is as in Malayan species. The frond is commonly rather thinner, with more regularly and narrowly oblong pinnæ, and less dissected margin, but these features are not at all constant. Van den Bosch described *C. Wilkesii* as with minutely dentate margin, and *C. australicum* as with upper margin obtusely, the lower one acutely dentate or setaceous. Rarely, however, Fiji specimens bear basiscopic projections (*Parks 20033*); and Samoan plants more often do so, or have the apices shallowly lacerate. New Hebrides specimens may exactly conform to the description of *C. australicum* (*Matheson*, Tanna), or may do so except that the sori are not at all immersed (*Kajewski*).

Guam, *Agr. Exp. Stat. 27,* mouth not greatly dilated, thus varying toward *T. atrovirens;* Carolines (New Caledonia, type locality of *C. australicum*); New Hebrides; Fiji and Samoa, common. Australian specimens doubtfully referred to this species have the lip less dilated and the margin minutely but more deeply cut than is typical.

99. TRICHOMANES FOERSTERI Rosenstock.

Trichomanes Foersteri ROSENSTOCK, Fedde's Repert. 13 (1914) 213.

Cephalomanes e grege *T. javanici* Bl., cum forma typica, a cl. v. d. Boschio in Hymen. javan., p. 31 descripta, omnino congruens, sed soris praes-

ertim apices pinnarum mediarum et inferiorum occupantibus, in pinnis superioribus ex apice secus marginem anteriorem plus minusve longe decurrentibus, indusiis usque ad apicem utrinque anguste marginatis, orificio dentibus papillosis c. 20–25 numero, 2–3-ies longioribus quam latis distincte ornato ab eo et ab affinibus diversa.

Sumatra occidentalis, c. 800 m alt., in alveis haud rara, 1913, l. W. Grashoff no. 43.—Rosenstock, loc. cit.

This must be a very distinct species, but I have seen no specimen. The involucres are described as bearing a crown like that of *T. superbum;* this might be deciduous, but I have seen no sign of such a structure in any *Cephalomanes.* The position of the sori on the several pinnæ is as in *T. asplenioides;* but the restriction of the fertile pinnæ to the middle and lower part of the frond is very remarkable.

100. TRICHOMANES MADAGASCARIENSE Moore.

T. madagascariense MOORE, Index (1861) 230.

Cephalomanes Madagascariense VAN DEN BOSCH, Synopsis (1859) 11.

Fronde oblongo-lanceolata pinnata, pinnis inferioribus horizontalibus contiguis, superioribus mediisque divaricatis cunctis breviter petiolatis e basi lata cordata inaequali oblongis, margine inaequaliter dentato-serratis, apice rotundatis, venulis remotiusculis 1–2 furcatis; cellulis maximis teneris elongatis hexaedris, parietibus rectis hyalinis, interaneis amorphis fuscescentibus seriatim radiatimque dispositis; soris subimmersis, mediotenus latius superne anguste marginatis, indusio cylindrico parum ventricoso, ore dilatato patulo recto.

Stipes triqueter glaber 0,1 et ultra longus, frons tenuis diaphana olivacea 0,15–0,18 longa, 0,03–0,04 lata, pinnae 0.010–0,016 longae, 0,006–8 latae.

Habitu et statura convenit cum *C. Zollingeri* et *C. curvato,* sororum forma cum *C. rhomboideo.*

Hab. Madagascar. Boivin in Herb. de Franqueville.—Van den Bosch, loc. cit.

The cordate pinnæ should distinguish this species clearly from all others known.

101. TRICHOMANES CRASSUM Copeland sp. nov. Plate 54; Plate 55, fig. 3.

Cephalomanes fronde longissima pinnatifida, caudice erecto breve; stipitibus fasciculatis, 1 ad 2 cm longis; fronde lineare, usque ad 40 cm longa, 4 ad 5 cm lata, utrinque angustata, ad alam costae sursum latam deorsum angustam ad pedem obsoletam pinnatifida, sordide atroviride, opaca, costa seu rhachi valida setis atrocastaneis deciduis vestita; segmentis patentibus oblongis, maximis 3 cm longis, 5 mm latis, obtusis, hic denticulato-crenatis, illic subintegris, margine inferiore facile revolutis, venis (cum affinibus comparatum) tenuibus et subremotis;

cellulis in gregi ob magnitudinem cellularum insigne tantum enormibus. Sori desunt.

Ins. Leyte Philippinensem habitat, ubi lexit *G. Lopez*, sub *Bur. Sci. no. 40804*. Typus in herb. Bur. Sci.; specimina etiam in U. S. Nat. Herb. et herb. auctoris.

Evidently a member of this group, but its most distinct species. Only so isolated a specimen would constrain me to describe it without fruit. The frond suggests *Athyrium porphyrorhachis*, or a *Polypodium* of the *P. pectinatum* group.

14. ABRODICTYUM; THE MONOTYPIC GROUP OF T. CUMINGII

102. TRICHOMANES CUMINGII C. Christensen. Plate 56, figs. 1 and 2.

T. Cumingii C. CHRISTENSEN, Index (1906) 638.

Abrodictyum Cumingii PRESL, Hymen. 113, pl. 7, diagnosis specifica in generica, p. 112, incorporata.

Habrodictyon Cumingii VAN DEN BOSCH, Hymen. Jav. 17, pl. 12.

T. Smithii HOOKER, Ic. Pl. pl. 704; Sp. Fil. 1: 138.

Venae prominulae, ramosae. Venulae crebrae, tenuissimae, flexuosae, in maculas irregulariter oblongas anastomosantes, ramosae, venulis secundariis pone marginem longitudinaliter decurrentibus, aliis intra maculas brevibus liberis obtusis. Cellulae intra maculas transverse lineari-hexagonae. Sorus exsertus, pedicellatus. Indusium infundibuliforme, limbo patente vel patentissimo integerrimo. Receptaculum indusio triplo longius, setaceum, basi capsuliferum. Capsulae sessiles, lenticulares. . . .

Incolit . . . insulas Philippinas, . . . Cuming . . . 208 et 358.—Presl, loc. cit.

Presl's description is better than his diagnosis (just quoted), but need not be quoted; botanists agree, as stated by van den Bosch, that "Phantasie magis quam veritati indulsisse videtur Cl. auctor."

Epiphytic on tree-fern trunks; rhizome short, its apex protected by a mass of castaneous bristles; stipes densely caespitose, 1 to 6 cm long, dark, wiry, bristly at the base; frond up to 27 cm long and 5 cm wide, commonly 10 cm long, sparingly tripinnatifid when well developed, commonly bipinnatifid, the rachis narrowly winged upward, or throughout on small forms, the lowest pinnæ reduced. The distal segments of the upper part of the frond commonly elongate, up to 2 cm long, and a scant millimeter wide; sori on short lateral segments throughout the frond; involucre campanulate to (usually) cylindrical, winged, with flaring and undulate mouth.

The salient characteristic is the cellular structure. Excepting the marginal, and in places the submarginal cells, the laminar cells are elongate at right angles to the axes of the seg-

ments, and are placed side by side in irregularly longitudinal rows tending to converge on the veins. The walls bounding these rows of cells were mistaken for veinlets by Presl. The veins are very slender, and false veinlets are absent. The walls are thickened and pitted in a manner suggesting the group of *T. rigidum,* to which, however, there is no near affinity. The pitting of the walls escaped van den Bosch; he may have figured a Tidore specimen, and it may be absent there.

Common in moist, tree-fern country, from northern Luzon to southern Mindanao and Palawan. Reported from the Moluccas (van den Bosch).

15. MACROGLENA; THE GROUP OF TRICHOMANES MEIFOLIUM

This collection of species is probably not one group, in the proper sense in which the word is used elsewhere in this treatise. The species have in common coarse rhizomes, whether creeping or erect, and very finely dissected fronds. Most species have notably large laminar cells, and many are brownish in color, with brownish cell contents closely appressed to the walls. Also, most species have more or less coarsely pitted walls. Both *T. setaceum* and *T. caudatum* and some relatives seem to be related to the group of *T. rigidum,* but this affinity may well be along independent lines.

Two early-described species, *T. parviflorum* and *T. angustatum,* are unknown to me; they may be represented by synonyms in my presentation. As the former was described from the region under review, its diagnosis and description are reproduced here.

TRICHOMANES PARVIFLORUM Poiret in Lamarck, Dict. Enc. 8 (1808) 83.

Trichomanes frondibus subtripinnatis; pinnulis pectinatis, petiolis hirsutis, fructificatione minimâ, incisuris inferioribus terminante.

. . . Ses racines sont composées de longues fibres épaisses, noirâtres, fasciculées: il s'en élève plusieurs feuilles pétiolées, droites, longues d'un pied, presque trois fois ailées, glabres, d'un vert-foncé, ovales-lancéolées, acuminées, composées de folioles alternes, rapprochées, lancéolées, acuminées; les pinnules alternes, divisées en découpures très-fines, simples ou bifides, capillaires, aiguës; les pétioles bruns, cylindriques, roides, chargées de poils fins, alongés, noirâtres. La fructification est fort petite, en forme d'entonnoir, située à l'extrémité des découpures inférieures; la columelle fine, saillante.

. . . Madagascar par M. du Petit-Thouars.—Poiret, loc. cit.

Key to the species.

Fronds fascicled.
  Segments linear.
    Walls conspicuously pitted .... 103. *T. strictum.*
    Walls not or hardly pitted .... 111. *T. Schlechteri.*
  Segments setaceous.
    Pinnules with undissected central area .... 104. *T. setaceum.*
    Dissection of fronds complete.
      Walls thickened and pitted .... 105. *T. laetum.*
      Walls thin .... 110. *T. meifolium.*
Rhizome creeping.
  Segments typically setaceous, squarrose .... 110. *T. meifolium.*
  Segments linear, not squarrose.
    Lateral walls thickened and pitted.
      Pinnæ (or some of them) caudate .... 106. *T. caudatum.*
      Pinnæ not caudate .... 107. *T. flavo-fuscum.*
    Walls slightly, irregularly thickened.
      Thickening reticulate .... 108. *T. Asae Grayi.*
      Thickening nodulose .... 109. *T. compactum.*
    Lateral walls uniformly thin .... 112. *T. gemmatum.*

103. TRICHOMANES STRICTUM Menzies. Plate 56, figs. 3 and 4.

T. strictum MENZIES, ex Hooker and Greville, Ic. Fil. (1831) pl. 122.

T. rigidum var. *strictum* FIELD, N. Z. Ferns 72, pl. 28, fig. 3.

T. leptophyllum A. CUNNINGHAM, Comp. to Bot. Mag. 2 (1836) 368.

Fronde lanceolata stricta pinnata, pinnis lanceolatis sub-bipinnatifidis, laciniis linearibus obtusis laxe reticulatis glabris integerrimis, involucris cyathiformibus ore aperto truncato integro, rachi marginata, stipite nudo.

Trichomanes strictum. *Menzies MSS.*

HAB. In sinu, Dusky Bay dicto, apud Novam Zeelandiam. *Menzies.*

Caudex, ut videtur, brevis, crassus . . . .

Stipes digitalis, erectus, strictus, fuscus, teres, nudus.

* * * * * * *

Sori rari, in singula pinna 1 vel 2, versus basin exteriorem segmentorum inferiorum inserti, laciniam brevem terminantes.

Involucrum cyathiforme, vix marginatum, ore dilatato, truncato, integro. . . . It is very distinct from any species we are acquainted with.—Hooker and Greville, loc. cit.

Stipes fascicled on a short, erect caudex, 5 to 8 cm tall, wiry, naked; fronds 10 to 15 cm long, lanceolate or lanceolate-ovate, with the lowest pinnæ usually but not always reduced, tripinnatifid, segments close but not numerous, about 0.5 mm wide, the lamina decurrent and forming a narrower wing on the rachis

and upper part of the stipe; laminar walls thick and coarsely pitted; sori on the lowest acropetal segments of the lowest acropetal pinnules, sessile, involucre cylindrical, winged, truncate, receptacle long-exserted.

New Zealand only.

The fascicled stipes, involucre, and wall structure mark this as a relative of the group of *T. rigidum*, but it is very distinct in appearance because of the fine and uniform dissection of the frond, the wing being as wide on the segments as on any of the coarser axes.

I have seen no New Zealand specimen named *T. leptophyllum*, and do not expect to unless it be very old, as all New Zealand botanists for the past eighty years have regarded it as completely identical with *T. strictum*. New Caledonia plants reported and distributed as *T. leptophyllum* are *T. caudatum*, with creeping rhizomes.

104. TRICHOMANES SETACEUM van den Bosch. Plate 57, fig. 1.

T. setaceum VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 176; Journ. Bot. Néerl. 1 (1861) 360.

T. trichophyllum MOORE, Gard. Chron. (1862) 45.

T. Merrillii COPELAND, Philip. Journ. Sci. 1 (1906) Suppl. 144, pl. 1.

Fronde oblonga acuminata bipinnata, pinnis divergentibus, infimis saepius reversis, contiguis oblongis vel oblongo-lanceolatis, pinnulis erecto-patulis subcontiguis oblongis lanceolatisve pinnatifidis, laciniis arcte contiguis strictis furcatis simplicibusve, lacinulis angustissime linearibus alte connatis inaequalibus in setam flexam curvatamque abeuntibus, rhachi valida dense palaceo-hirsuta, venis tenuibus, venulis densissimis parallelis, cellulis magnis firmis opacis elongato-hexaëdris, parietibus hyalinis acute crenulatis (quasi spinulosis), interaneis amorphis spissis diffusis ex aureo obscure infuscis, soris in laciniis pinnularum infimis axillaribus parvis emersis, indusio vix conspicue marginato compresso cylindrico-infundibuliformi orificio recto, stipitibus e rhizomate brevissimo adscendente polyrrhizo fasciculatis in basin fusco-pilosam incrassatis glabrescentibus 10–18 cent. longis. Frons 15–20 cent. longa, 5–7 lata rigidula gracilis ex obscure viridi olivacea.

* * * * * * *

Hab. Singapore, GAUDICHAUD (H. Berol.); Ins. Banca (pr. Mintole.), AMAN.—Van den Bosch, loc. cit.

The rhizome of well developed plants is stout and erect, concealed by a mass of roots and stipes; stipes densely and fairly permanently bristly, ranging on fertile fronds from 3 to 16 cm in length; fronds 10 to 20 cm long, lanceolate to oblong, the basal pinnules sometimes reduced and sometimes deflexed; pinnæ imbricate, broadly elliptic, obtuse; pinnules pinnate to a winged axis, into secondary pinnules pinnatifid to a restricted

axial lamina with many long, setaceous segments; laminar walls thick, with large pits, appearing zigzag or toothed in exact focus, the frond thus having the texture of the less coriaceous members of the *T. rigidum* group, but still being harsh because composed mostly of the axes.

I have seen no authentic specimen of *T. trichophyllum*, but the original description is perfectly appropriate to large specimens of this species. The *T. trichophyllum* of Baker, Syn. Fil. 2d ed. 466, is redescribed to fit a very distinct plant of New Caledonia, *T. laetum*.

It was my former impression that *T. setaceum* (as *T. Merrillii*) was intermediate between *T. obscurum* and *T. meifolium*, and perhaps also between *T. obscurum* and *T. javanicum* with *T. rhomboideum* as another intermediate in the latter series. It may be, however, that it has no affinity except to the *T. rigidum* group; and that *Cephalomanes* and *Macroglena* are independent derivatives of the group of *T. radicans*.

BORNEO, common in Sarawak and British North Borneo, *Burbidge; Hose; Ridley; Bur. Sci. 2504 native collector; Clemens 9493, 22019; Ramos 1121, 1319; Bartsch 189; Topping 1369*. PERAK, *Murton*. PHILIPPINES, Palawan, *Merrill 716* (type of *T. Merrillii*).

105. TRICHOMANES LAETUM van den Bosch. Plate 57, fig. 2.

T. laetum VAN DEN BOSCH, Ann. Sci. Nat. IV 15 (1861) 90; FOURNIER, Ann. Sci. Nat. V 18: 260.

T. trichophyllum BAKER, Syn. Fil. 2d ed. 466 partim, non Moore.

T. Marierii VIEILLARD in herb., and in Baker, loc. cit., nomen nudum.

T. Luerssenii F. v. MÜLLER in Luerssen, Bot. Centralb. 9 (1882) 440.

Fronde lanceolata tripinnatifida, laciniis erecto-patulis contiguis (tertiariis appressis), lacinulis setaceis elongatis flexuosis, cellulis fere hyalinis parvis irregularibus punctulatis amoene viridibus minute globulosis acute crenulatis, serie 1 vel 2 utrinque juxta venulas laciniarum laminam constituentibus, soris in laciniis secundariis axillaribus subsessilibus anguste cylindricis, limbo parumper constricto. Rhizoma adscendens valde radiculosum fusco-hirsutum stipites valde approximatos (5–8 centim. longos) flexuosos angustissime alatos, pariter ac rachis compressa, frondi concolores emittens; frons 10–12 centim. longa, 3–4 lata rigida viridis.

Hab. ad filicum caudices, Balade [New Caledonia] VIEILLARD, herb. n. 1665.—Van den Bosch, loc. cit.

Reduced to "T. Pluma vel T. trichophyllum" in Christensen's Index.

Rhizome ascending and finally erect, covered by roots and stipes in the manner of the group of *T. rigidum;* stipes maroon,

wiry, glabrescent; fronds lanceolate, or ovate if dwarfed, two to four times pinnate and the pinnules repeatedly dichotomous, the ultimate segments exceedingly fine, and spreading in all directions, with the aspect of an exceptionally finely dissected *T. meifolium;* lamina 1, rarely 2, cells wide, or wanting, all walls thick, coarsely and conspicuously pitted; sori much farther from the main axes than in *T. meifolium,* but still not nearly reaching the outline of the frond; involucre short- or long-cylindrical, mouth commonly slightly bilabiate without being dilated.

NEW CALEDONIA, *Vieillard 2139; Franc 473, Rosenstock Fil. Nov. Caled. 29; le Rat 293,* in part.

However similar in aspect to compact specimens of *T. meifolium,* this species may not be even its near relative. The fascicled stipes, position of sori, and form of involucre, and the pitting of the walls, altogether, establish a more certain affinity to the group of *T. rigidum.* I have construed this species by *Vieillard 2139,* represented in the Gray Herbarium and in the herbarium of the Bureau of Science; it is the only Vieillard specimen cited by Fournier.

Trichomanes Luerssenii was described from the New Hebrides, and compared with six other species, but not with *T. laetum.* The description is good enough to seem to establish its complete identity.

106. TRICHOMANES CAUDATUM Brackenridge. Plate 57, figs. 3 to 5; Plate 58, fig. 1.

T. caudatum BRACKENRIDGE, U. S. Expl. Exped., Bot. 16 (1854) 256, pl. 36, fig. 5.

T. Milnei VAN DEN BOSCH, Ann. Sci. Nat. IV 15 (1861) 89.

T. leptophyllum FOURNIER, BAKER, CHRISTENSEN, as to N. Caledonia.

HAB. Tahiti, Society Islands: on trees in mountain forests.

Rootstock short and thick, creeping, densely *tomentose* with brownish short hairs. *Stipe* about 2 inches long, *terete* slightly *rough* to the touch. *Fronds* very graceful, and in a dry state quite *elastic,* 10 to 15 inches long by 3 inches broad, *elongated-lanceolate, pinnate,* and as well as the *oblong-lanceolate* and *bipinnatifid pinnæ* (which are rather *distant at the base*) tapering into a narrow, *tail-like,* serrate point. Pinnules or secondary divisions approximate and somewhat imbricated; the ultimate ones less so; these are *narrow-linear,* short and *obtuse,* their apices either *simple or bifid. Rhachis* round at the base, *narrowly-winged* upwards, and slightly scabrous on the under side. Veins throughout very thick and prominent. Sori copious all over the frond. *Indusium cylindrical,* with an *attenuated base* and a *spreading, entire mouth,* seated on a short *supra-axillary* lacinia, or else *terminal, partially* immersed, or with *two wings,* which are sometimes

so narrow as scarcely to be perceptible. *Receptacle exserted,* about twice the length of the indusium, and quite straight.

This is closely related to the *T. angustatum* of Carmichael, as figured in Hooker and Greville's Icones Filicum.—Brackenridge, loc. cit.

The type collection seems to have been a single frond, since it is not represented in the Gray Herbarium. It represents the species in its fullest and most symmetrical development. Most Tahiti collections have the larger fronds about 20 cm long, with the caudate pinna tips developed here and there on the frond; and on small fronds these tips may not be very elongate on any pinnæ. These small and middle-sized fronds are perfectly duplicated by specimens from Fiji, and by the larger specimens from New Caledonia, received as *T. leptophyllum* and *T. Milnei,* the last averaging the smallest.

Rhizome creeping, 1 to 1.5 mm in diameter, with stipes 1 cm or more apart; stipes 2.5 to 5 (rarely to 10) cm long, slender, terete, naked. The walls of laminar cells are moderately thickened, and conspicuously pitted; the cells larger and the pits smaller than in the group of *T. rigidum,* to which there is resemblance and probable affinity. In both Tahiti and New Caledonia material I find the pits commonly larger than they are figured by Mettenius, Hymenophyllaceae, pl. 3, figs. 5, 49, 50. The brownish content of the cell is applied en masse to some of the lateral walls, most often the longitudinal, on one or both sides of the cell, producing under low magnification the appearance of false veins. This is responsible for the statements, Fournier, Ann. Sci. Nat. V 18: 254, Copeland, Bishop Mus. Bull. 59: 26, that the cellular structure suggests *Abrodictyum.* However, I have seen instances, in this group and in *T. dentatum,* in which the pits happen to be in transverse rows, the resemblance to *Abrodictyum* then being real.

In spite of the difference in rhizome, *T. caudatum* and *T. strictum* are surely related. In the original descriptions, both were compared with *T. angustatum* Carm., known only from Tristan d'Acunha, which I have never seen. *Trichomanes tenerum* Spr., of South America, which has been suspected of being *T. angustatum,* is no relative of this Polynesian group (it is near *T. pyxidiferum*) ; but it would not surprise me, in spite of its geographical remoteness and the bilabiate involucre described for it, to find *T. angustatum* identical with either Polynesian plant.

TAHITI, *Brackenridge* (the type), *Vesco, Setchell and Parks 538, Grant 4222.* RAROTONGA, *Wilder 1050.* SAMOA, *Whitmee.*

FIJI, *Seemann 783, Horne 520, Prince, Parks 20770, 20808 partim.* NEW CALEDONIA, *Le Rat 275, 2848, Cribs 481, Franc 68, Rosenstock, Fil. Nov. Caled. 136.* QUEENSLAND, *Simmonds, Schneider, White.*

107. TRICHOMANES FLAVO-FUSCUM van den Bosch. Plate 58, fig. 2.

Trichomanes flavo-fuscum VAN DEN BOSCH, Ann. Sci. Nat. IV 15 (1861) 88.

Fronde e rhizomate horizontali validissimo fasciato-contorto rubro-fusco-tomentoso ovato-lanceolata inferne pinnata, superne pinnatifida, laciniis 2–3 pinnatifidis erecto-patulis, primariis remotis, secundariis contiguis, lacinulis appressis abbreviatis linearibus, cellulis teneris magnis poroso-punctatis minutissime denticulatis flavis, marginalibus aurantiacis, soris numerosissimis in laciniis ultimis axillaribus lateralibusque urceolatis parvis anguste marginatis, stipite (usque 6 centim. longo) valido terete, rachi superne anguste alata badio-fusca. Frons 2 decim. circiter longa, supra basin 10 cent. lata, dehinc sensim angustata e flavescente obscure viridi-fusca.

Hab. Ad caudices filicum arborescentium in M. de Balade [New Caledonia], Vieillard, herb. n. 1653, 1655 et 1656.—Van den Bosch, loc. cit.

This has been reduced to *T. caudatum* by Luerssen, Baker, and Christensen. It is near to that species but is a distinctly less delicate fern, with stouter stipe, firmer, broader, more compact frond, a deep, dark brown in color, and at most acuminate but not caudate pinnæ. As far as I know, no author has tried to combine this with *T. Milnei,* which seems to me to be merely a small *T. caudatum.*

NEW CALEDONIA, cotype, bearing all three numbers cited by van den Bosch, in Herb. Bur. Sci.; *Cribs 482* (as *T. caudatum*); *Le Rat 955* (as *T. caudatum*); *Franc 344, Rosenstock, Fil. Nov. Caled. 6* (as *T. elongatum*).

108. TRICHOMANES ASAE-GRAYI van den Bosch. Plate 61, fig. 1.

T. Asae-Grayi VAN DEN BOSCH, Ned. Kruid. Arch. 5 (1861) 180; Journ. Bot. Néerl. 1 (1861) 362.

T. ericoides DRAKE, Flore Polyn. Franc. 275, whether or not of Hedwig.

T. longisetum BRACKENRIDGE, and CARRUTHERS, Fl. Vitiensis 344, non Bory.

T. asae grayi; T. longisetum Brack. (non Bory) in WILK. expl. exped. XVI p. 260.

T. gemmato proximum, neque *T. longiseto* . . . affine; ab illo autem distinguatur; fronde minus divisa angustiore graciliore, laciniis primariis basi quidem strictis, sed mox divergentibus recurvisque imbricatis, secundariis erecto-strictis pinnatifidis (nunquam bipinnatifidis), lacinulis ½ angustioribus evidentius membranaceis subcontiguis strictiusculis (ultimis nunquam forcipatis), cellulis mediocribus vix magnis (in illo maximis oculo

nudo fere distinguendis) parietibus minute denticulato-crenulatis, soris ⅓ minoribus ex urceolato cylindricis, ore integro recto.

* * * * * * *

Hab. Ins. Fidchi (ad truncos in sylvis montanis rarum), WILKES.—Van den Bosch, Ned. Kruid. Arch. 5 (1861) 180.

The cotype in the United States National Herbarium is without rhizome, as is also a Samoa specimen, *Jansen,* in the Singapore herbarium. *Quayle 47,* from Tahiti, has an erect, but somewhat elongate and contorted rhizome with the stipes not closely fascicled. All are certainly one species, distinguishable from *T. gemmatum* by having the laminar walls slightly reticulate-thickened; the Fiji and Tahiti specimens are alike in having more slender involucres, but the Samoa one has these as in *T. gemmatum.* Other Samoa specimens too similar to this to be safely distinct have uniformly thin walls, and are regarded as *T. meifolium.* It is possible that all these ought to be called *T. parviflorum;* not being sure what that species is, I let them stand as *T. Asae-Grayi.* The frond is as broad as that of *T. gemmatum,* or broader.

109. TRICHOMANES COMPACTUM v. A. van Rosenburgh in herb. Plate 59.

Caudice valido, adscendente, basibus stipitum radicibus et setis atrocastaneis densis profunde obtecto; stipitibus fasciculatis, 10 cm altis, praecipue deorsum dense squarroso-setosis; fronde 25 cm alta, 8 cm lata, 3- ad 4-pinnatifida, rhachi valida castanea setosa; pinnis subpatentibus usque ad 9 cm longis, 10 ad 14 mm latis, sessilibus, acuminatis; pinnulis imbricatis; segmentis proximis, 0.6 mm latis; cellulis maximis, utroque latere venae in seriebus 2 ad 3 instructis, parietibus tenuibus, nodoso-crenulatis, interaneis fuscis ad parietes appressis; involucro cupuliforme, anguste alato, truncato.

NEW GUINEA, Doormankop, *Lam 1559,* altitude 1,420 m; *Lam 1721,* altitude 3,200 m.

A relative of *T. flavo-fuscum,* distinguished by stout caudex, congested stipes, and copious dark bristles. I have not located publication of this species, and have described it from specimens in the Singapore herbarium, as there named.

110. TRICHOMANES MEIFOLIUM Bory.

T. meifolium BORY ex Willdenow Sp. Pl. 5 (1810) 509; KAULFUSS, Enum. 265, pl. 2.

T. ericoides HEDWIG (1805) nomen nudum.

T. longisetum BORY in Willd. Sp. Plant. 5: 510; VAN DEN BOSCH, Hymen. Javan. 28, pl. 21.

T. foeniculaceum HOOKER, Sp. Fil. 1: 135, non Bory.
T. Pluma HOOKER, Ic. Plant. pl. 997.
T. gemmatum J. SMITH: Baker, Syn. Fil. 87, in part.

T. frondibus triplicato-pinnatis, pinnis horizontaliter patentibus rigidis, pinnulis tereti-capillaceis dichotomis incurvatis, rachi setosa, receptaculis filiformibus indusio parum longioribus. W.

T. fronde lineari-lanceolata pinnata, pinnis decompositis capillaribus subteretibus, laciniis imbricatis *Bory in litt.*

Bärwurzelblättriger Becherfarrn. W.

Habitat in sylvis montium insulae Borboniae. (*v. s.*)

Stipes *quadri- vel quinquepollicaris teres canaliculatus glaber superne setis aliquot raris obsitus.* Frons *quinquepollicaris triplicato-pinnata atrovirens, exacte facie Aethusae Mei.* Pinnae *primariae octolineares rigidae horizontaliter patentes; secundariae capillaceae trilineares teretes.* Pinnulae *dichotomae capillaceae teretes apicibus inflexis.* Indusia *cyathiformia basi attenuata pedicellata pinnulis inserta.* Receptaculum *indusio parum longius filiforme.* Rachis *universalis setis subulatis patentibus obsita, partialis hinc inde punctis prominentibus exasperata. Dignoscitur facile tenuitate et rigiditate frondis. W.*—Willdenow, loc. cit.

Although better described than were most species in its time, *T. meifolium* has been ill understood and appreciated, partly because described under another name, *T. longisetum,* at the same time, partly because of the use of a prior nomen nudum, *T. ericoides,* partly because of Hooker's reference to it of *T. foeniculaceum* Bory and *T. bauerianum* Endl., and finally and worst because of its effective supplanting by *T. Pluma.* Without seeing a really authentic specimen, I construe it confidently by Kaulfuss's illustration, and the identification with *T. meifolium* by Kuhn, Fil. Afric. 34, who had at hand the types, of *T. longisetum,* described and figured by van den Bosch in Hymen. Javanicae. Before we stood on our own feet in dealing with Philippine ferns, we had this species with identifications by European specialists, as *T. meifolium, T. foeniculaceum, T. gemmatum,* and *T. Pluma,* and in turn distributed it under all of these names; and it is only very recently that I have come to the conclusion that *T. Pluma,* which some of our specimens certainly represent, is only a luxuriant form, likely to develop wherever the slightly more lax typical form appears.

The value of the nature of the rhizome, creeping or scandent in most of the sections of the genus, more or less erect and with fascicled stipes in others, is obscured in this species by its irregularity. It is in all cases really creeping; but is not rarely so short that any difference between approximate and fascicled stipes is easily overlooked. On a single rhizome, I have found numerous stout stipes spaced 2 to 3 mm apart—and thus, since

the rhizome was there contorted, densely tufted,—and in another long and straight part, 3.5 cm apart. They are more commonly remote enough to relieve the fronds from mutual competition; also the fact that the form with long rhizomes makes pretty specimens may not escape the collector. The stipes are approximate on "typical" *T. meifolium* and *T. Pluma.* The rhizome is 1 to 2.5 mm in diameter.

The fronds are never plane. They vary greatly in this respect, but some twisting and/or bending of the minor axes, so that their divisions are directed well out of the general plane of the frond, is never absent. There is wide diversity also in the closeness of the branching, and therefore in the number of pinnules and segments, and therefore in the density of the frond; a mounted frond may leave visible a large part, or almost none, of the underlying paper.

The segments are always fairly termed setaceous; but this may mean that the axes bear no wing, which is not unusual, or that the wing is inconspicuous. Kaulfuss depicted one row of laminar cells; van den Bosch, one or two. The range from none to two can be found on single fronds. On a number of specimens, I find some segments with a lamina up to four cells wide, conspicuous to the naked eye, on otherwise normal fronds—superfluous evidence of an ancestry with better developed lamina. A wing like that on the segments is borne on all axes of the frond, even the main rachis, and most of the setæ spring from it. Even if the wing be obsolete on the segments, it is present on the rachis.

The laminar cells may be isodiametric, or somewhat elongate along the axis of the segment. Their walls are uniformly thin, straight or curved but never wavy. The brown content is closely applied to the lateral, but not normally to the marginal walls.

The sori are borne on short basal segments, on either side of the axes of the pinnules. The short pedicel is winged if other segments are, and the wing is sometimes evident part way up the involucre—or rarely all the way. The involucre is small, elongate-obconic, or with parallel sides in the upper part, opaque, perfectly truncate or rarely slightly dilated at the top.

(Madagascar). Réunion (Bourbon), *de l'Isle 102, 358,* in the United States National Herbarium. Throughout the Malay region, common in the mossy forest, on trunks and terrestrial, north to central Luzon. Amboina, *Robinson 1966.* Papua, *Schlechter 18687, 19623,* as *T. Pluma* (I cannot distinguish the

var. *alatum*). New Caledonia, *Cribs 1334*. New Hebrides, *Kajewski 867*. Samoa. Some Samoan specimens (*Vaupel, Powell, Whitmee*) show a trace of reticulation on some walls; another collection (*Reinecke 188*, in United States National Herbarium) has uniformly thin walls, but more the aspect of *T. gemmatum*. A Queensland collection, *Waller s. n.* ex Nat. Herb. N. S. W., distributed as *T. parviflorum*, may be suspected of being *T. setilobum* F. v. M., nomen, and is probably specifically distinct; it has uniformly thin walls, but the pinnules are incompletely dissected into setiform segments.

The varieties *linearis* and *contracta* of Brause, Bot. Jahrb. 56 (1920) 39, are unknown to me, but appear to be forms rather than varieties. The fronds vary everywhere from linear to lanceolate, and very stunted ones are commonly relatively broad, and congested. They may be less than 5 cm long on dwarfed old plants, and bear some sori.

Trichomanes Schultzei Brause, Bot. Jahrb. 49 (1912) 8, said to be a relative of *T. strictum*, seems from the description to be more like a lax form or relative of *T. meifolium*.

111. TRICHOMANES SCHLECHTERI Brause. Plate 60.

Trichomanes Schlechteri BRAUSE, Bot. Jahrb. 49 (1912) 10.

Eutrichomanes. Rhizoma erectum, crassum, pilis rufo-brunneis dense vestitum. Petioli fasciculati, validi, brunnei, 3,5–6 cm longi, 1,2–1,8 mm crassi, teretes, striati, pilis articulatis rubiginosis, usque ad 8 mm longis, tortis muniti. Laminae ambitu lineari-lanceolatae, usque ad 36 cm longae, cr. 3,5 cm latae, ad basin versus decrescentes, in apicem obtusiusculum desinentes, subquadripinnatifidae, olivaceae, pellucidae, glabrescentes; pinnis plus minusve 40-jugis, ambitu deltoideis, suboppositis, usque ad costam angustissime alatam partitis, subtripinnatifidis, patentibus, petiolulatis, medianis maximis 2–2,5 cm longis, basi cr. 1,8 cm latis; segmentis primariis bipinnatifidis, pinnatifidis vel linearibus, cr. 9–jugis, imbricatis, ala angusta continuis; segmentis secundariis pinnatifidis vel furcatis; laciniis numerosis, vix 0,3 mm latis, usque ad 0,8 cm longis, margine integris; rachibus costisque validis, pilis iis petioli similibus dense instructis, costis anguste alatis. Sori segmentis secundariis infimis anticis impositi, uniseriales in utroque costae latere; indusio basi anguste marginato, cupuliformi, orificio parum angustato; receptaculo longissime exserto.

* * * * * * *

Nordöstl. Neu-Guinea: Kaiser-Wilhelmsland, auf Bäumen in den Wäldern des Dischore, ca. 1200 m ü. M. (Schlechter n. 19612.—29. Mai 1909).

Gehört in den Formenkreis von *T. longisetum* Bory. . . . bei *T. longisetum* ist der Blattstiel länger und kahl, die Blattfläche mehr dreieckig. . . .—Brause, loc. cit.

An exceptionally well-marked species, with densely bristly axes, the dark-chestnut setæ on the stipe reaching a length of 3

mm; fronds long and linear, the lower pinnæ gradually much reduced and hardly imbricate; the pinnæ and their divisions in the middle and upper part of the frond the most densely imbricate in the genus. The brown lamina is three or four cells wide; the cells elongate obliquely to the costa; marginal walls thin, all other lateral walls thick, inconspicuously and irregularly pitted, and in places no pits visible.

Besides a cotype, I have in hand, from the Singapore and Bureau of Science herbaria, an unnumbered collection by Boden Kloss (as *T. ericoides*), from M. Carstensz, Dutch New Guinea, Camp VIb.

112. TRICHOMANES GEMMATUM J. Smith. Plate 61, fig. 2.

Trichomanes gemmatum J. SMITH in Hooker's Journ. Bot. **3** (1841) 417 (nomen); BAKER, Syn. Fil. (1867) 87.

Rhizome strong, wiry, tomentose, beset with numerous long black wiry fibres; *st.* 1–3 in. l., naked, wiry, winged above; *fr.* 2–6 in. l., 1–2 in. br., erect, subrigid, ovate-oblong, bipinnatifid; main *rachis* narrowly winged; *pinnae* erecto-patent, cut down to a narrowly-winged rachis; lower *pinnl.* deeply forked with subrigid, linear-filiform *segm.* 1½–2 lin. l., cellules large; *sori* 1 to 8 to a pinna, minute, axillary, the tube turbinate, stalked, the mouth nearly truncate.—Baker, loc. cit.

As Baker takes up the name of J. Smith, the type is the only specimen cited by Smith, *Cuming 400,* from Malacca.

Distinguished from *T. meifolium* by somewhat broader and far less numerous segments. The laminar wing is mostly only two or three cells wide, but these cells are large, so that the segments are linear rather than setaceous. The wing continues far down the stipe, but may be broken off there. The pinnæ are conspicuously broad, and therefore imbricate, but there is no conspicuous departure of pinnules or segments from the plane of the frond. The pinnules being long, their pinnate plan is evident; but this distinction from *T. meifolium* is in degree only, as in the latter species also they are pinnate, the fact being commonly obscured by wealth of fairly equal segments. The cell walls are uniformly thin, or very slightly and irregularly thickened. Rhizome creeping; stipes usually approximate.

Superficially, this is exceedingly like the Polynesian species (*T. Asae-Grayi*) which has been called *T. parviflorum*; but the latter has thicker and distinctly pitted walls and fascicled stipes. Which, if either, is true *T. parviflorum,* I do not know, and under the circumstances leave them with the names authenticated by typical specimens.

MALACCA, *Cuming 400*, cotypes in Gray Herb., U. S. Nat. Herb., Bur. Sci. herb., and herb. Copeland. MOUNT OPHIR, *Brackenridge* (as *T. foeniculaceum*); *Wight 241; Hose; Ridley; Derry 607*. PAHANG. KELANTAN. BORNEO, *Hewitt 33*. A single Philippine specimen, *Calvin 332*, from Mount Banahao, Luzon, seems to be *T. gemmatum*, but, unless it can be found to be established there, it may be an aberrant *T. meifolium*. The two seem to be quite distinct in Malacca.

Genus CARDIOMANES Presl

Costa nulla. Venae pedato-flabellatae, crebrae, furcatae, steriles ante marginem frondis apice obtuso desinentes. Sorus intramarginalis, immersus. Indusium campanulatum, ore integrum. Capsulae lenticulares, receptaculo clavato obtuso demum exserto undique affixae.—Presl, Hymenophyllaceae (1843) 104.

Construing *Trichomanes* in the broadest sense, this is the only really isolated species in the Old World, nor is there any comparatively isolated group of species. Accordingly, in an era of genus-splitting, this is the only one of the many genera carved from *Trichomanes* by Presl and his immediate successors clearly enough definable to make its maintenance expedient.

Rhizome stout, creeping, terrestrial; stipes rigidly erect; frond reniform, coriaceous, several cells in thickness; venation flabellate-dichotomous; sori contiguous around the outer border, receptacle cylindrical. A single species, native of New Zealand.

CARDIOMANES RENIFORME (Forster) Presl.

C. reniforme (Forster) PRESL, Hymen. (1843) 105.

Trichomanes reniforme FORSTER, Prodromus (1786) 84; SCHKUHR, Kryptog. Gewächse 130, pl. 134; HOOKER and GREVILLE, Ic., pl. 31.

Frondibus simplicibus reniformibus stipitatis multifloris, receptaculis seminum exsertis cylindricis. F.

Nova Zeelandia.—Forster, loc. cit.

The characters are those of the genus. The fronds reach a diameter of 8 cm or more. Although it has never become common, this fern has long been in cultivation. Herbarium specimens purporting to be from Hawaii and Fiji may have escaped from gardens.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Trichomanes pyxidiferum.* Natal, *Wood; Herb. Univ. Calif. 398318*, sorus, × 15.
2. *Trichomanes stenosiphon.* Type, sorus, × 15.
3. *Trichomanes parvum.* Type, sorus, × 15.
4. *Trichomanes draytonianum.* Type, tip of segment, × 150.
5. The same specimen, sorus, × 15.
6. The same specimen, margin of lip, × 150.
7. The same specimen, margin of frond, × 330.

PLATE 2

FIG. 1. *Trichomanes schmidianum.* Cotype (?), in Gray Herb., sorus, × 15.
2. *Trichomanes Hosei.* Cotype, in Herb. Singapore, frond, × 1.
3. The same specimen, detail of cellular structure, × 400.
4. The same specimen, sorus, × 15.

PLATE 3

FIG. 1. *Trichomanes Colensoi. Herb. Univ. Calif. 398321*, frond, × 1.
2. The same specimen, detail of structure, × 400.
3. The same specimen, sorus, × 15.

PLATE 4

FIG. 1. *Trichomanes latifrons.* A Luzon specimen, *For. Bur. 16318*, frond, × 1.
2. The same specimen, sorus, × 15.
3. The same specimen, detail of structure, × 400.
4. The same species, primary segment of cotype (?), in Gray Herb., × 5.
5. Gray Herb. specimen, sorus, drawn wet, × 15.

PLATE 5

FIG. 1. *Trichomanes parvulum.* Tahiti specimen, *Grant 5282*, × 2.
2. The same specimen, detail of structure, × 400.
3. The same specimen, sorus, × 15.

FIGS. 4 and 5. Yunnan specimens, *Hancock 136*, in U. S. Nat. Herb., laminæ, × 2.

PLATE 6

FIG. 1. *Trichomanes Teysmannii. Raciborski 626*, in Herb. Bur. Sci., frond, × 1.
2. The same specimen, detail of structure, × 400.
3. The same specimen, sorus, × 15.

FIGS. 4 and 5. *Trichomanes alagense.* Cotype, fronds, × 2.

FIG. 6. The same specimen, detail of structure, × 400.
7. The same specimen, sorus, × 15.

PLATE 7

FIG. 1. *Trichomanes nitidulum.* From Java, *Copeland.*
2. *Trichomanes Francii.* Cotype.
3. *Trichomanes digitatum.* From Mauritius.
4. *Trichomanes digitatum.* From Luzon, *Robinson.*
5. *Trichomanes dichotomum.* From Java, *Raciborski.*
6. *Trichomanes palmatifidum.* From Sumatra, *Winkler 111.*
7. *Trichomanes Lyallii.* From New Zealand, *Ranft.*

PLATE 8

FIGS. 1 and 2. *Trichomanes sibthorpioides. Hillebrand* in Madagascar, in Herb. Copeland, fronds, × 4.
3. The same specimen, detail of structure, × 400.
4. The same specimen, sorus, × 15.
5. The same specimen, sorus with one dichotomous lip.

PLATE 9

FIG. 1. *Trichomanes vitiense. Bauerlein* in New South Wales, fertile frond, × 5.
2. The same specimen, detail of structure, × 330.
3. *Trichomanes liberiense.* Type, sterile frond, × 10.
4. The same specimen, fertile frond, × 10.
5. The same specimen, detail of structure, × 400.
6. The same specimen, sorus, × 15.

PLATE 10

FIG. 1. *Trichomanes taeniatum.* Type, frond, scale shown.
2. The same specimen, frond, × 2.
3. The same specimen, sorus, × 15.
4. The same species, *Grant 4401,* sorus.

PLATE 11

FIG. 1. *Trichomanes palmatifidum. Herb. Univ. Calif. 391828,* sorus, × 25.
2. *Trichomanes Ridleyi.* Type, frond, × 2½.
3. The same specimen, sorus, × 25.
4. *Trichomanes Lyallii. U. S. Nat. Herb. 817020,* sorus, × 25.

PLATE 12

FIG. 1. *Trichomanes humile.* Tahiti specimen, *Setchell and Parks 214,* detail of structure, × 75.
2. The same specimen, detail of structure, × 400.
3. The same specimen, sorus, × 15.
4. *Trichomanes filiculoides. Lauterbach 541,* frond, × 2.
5. The same specimen, detail of structure, × 400.
6. The same specimen, sorus, × 15.

PLATE 13

FIG. 1. *Trichomanes gracillimum.* Type, frond, × 2.
2. The same specimen, detail of structure, × 400.
3. *Trichomanes gracillium.* Mount Masingit specimen, *Bur. Sci. 37576,* frond, × 2.
4. The same specimen, detail of structure, × 400.

PLATE 14

FIG. 1. *Trichomanes endlicherianum.* Norfolk Island specimen, *Herb. Copeland 2312,* frond, × 1.
2. The same specimen, detail of structure, × 400.
3. The same specimen, sorus, × 15.
4. *Trichomanes tenue.* Cotype, in Gray Herb. sorus, × 15.
5. The same specimen, detail of structure, × 400.
6. The same specimen, × 75.

PLATE 15

FIG. 1. *Trichomanes endlicherianum.* Cotype of *T. erectum,* in Gray Herb., frond, × 1.
2. The same specimen, detail of structure, × 75.
3. The same specimen, detail of structure, × 400.
4. The same specimen, sorus, × 15.
5. *Trichomanes Naumannii.* Cotype, *U. S. Nat. Herb. 340498,* frond, × 2.
6. The same specimen, detail of structure, × 400.
7. The same specimen, sorus, × 15.

PLATE 16

FIG. 1. *Trichomanes Werneri. Schlechter 17304 (Herb. Univ. Calif. 391768* in part), frond, × 2.
FIGS. 2 to 4. The same specimen, detail of structure, × 75 and 400.
5 and 6. The same specimen, sorus, × 15.

PLATE 17

FIGS. 1 to 3. *Trichomanes Vieillardii. Franc 830 (Herb. Copeland 10914),* fronds, × 2.
FIG. 4. The same specimen, detail of structure, × 400.
5. The same specimen, sorus, × 15.
6. The same species. *Rosenstock, Fil. Nov. Caled. 135,* in Herb. Bur. Sci., frond, × 2.
7. The same specimen, detail of structure, × 400.
8. The same specimen, sorus, × 15.

PLATE 18

FIG. 1. *Trichomanes bipunctatum.* From Mauritius, *U. S. Nat. Herb. 593140,* detail of structure, × 75.
2. The same specimen, × 400.
3. The same specimen, sorus and venulation, × 15.
4. The same species. Fiji specimen, *Parks 20638,* detail of structure, × 75.
5. *Trichomanes bilabiatum. Palmer and Bryant 315,* venulation, × 75.
6. The same specimen, sorus, × 15.

PLATE 19

FIG. 1. *Trichomanes latemarginale.* Type collection, × 4.
2. *Trichomanes rupicolum.* Type collection, × 4.
3. *Trichomanes pervenulosum.* Type collection, × 4.
4. *Trichomanes Nymani. Schlechter 16610,* × 4.

PLATE 20

FIG. 1. *Trichomanes brevipes. Cuming 2,* probably the cotype of *T. brevipes,* in Gray Herb., venulation, × 75.

2. The same specimen, sorus, × 15.
3. *Cuming 316.* Cotype of *T. melanorhizon,* in Gray Herb., venulation, × 75.
4. The same specimen, sorus, × 75.
5. *Cuming 150.* Substantial cotype of *Crepidomanes,* in Gray Herb., venulation, × 75.
6. The same specimen, sorus, × 15.
7. Cotype of *Trichomanes anomalum,* in U. S. Nat. Herb., sorus, × 15.

PLATE 21

FIG. 1. *Trichomanes Christii.* Type, in Herb. Bur. Sci. frond, × 1.

2. The same specimen, detail of structure, × 400.
3. The same specimen, sorus, × 15.
4. The same species, *Bur. Sci. 41743,* venulation, × 75.
5. The same species, sorus, × 15.

PLATE 22

FIG. 1. *Trichomanes venulosum. Schlechter 16370* (*Herb. Univ. Calif. 227254*), venulation, × 75.

2. The same specimen, sorus, × 15.
3. *Trichomanes pervenulosum.* Cotype, in Herb. Bur. Sci., fertile fronds, × 5.
4. The same specimen, venulation, × 70.

PLATE 23

FIG. 1. *Trichomanes intramarginale. C. P. 3361,* in Gray Herb., frond, × 2.

2. The same specimen, detail of structure, × 400.
3. The same specimen, sorus, × 15.
4. *Trichomanes megistostomum.* Type, lamina, × 2.5.
5. The same specimen, sorus, nearly dry, × 15.
6. The same specimen, sorus, wet.

PLATE 24

FIG. 1. *Trichomanes latemarginale.* Probable type, *U. S. Nat. Herb. 51149,* venulation, × 75.

2. The same specimen, sorus, × 15.
3. The same species, ex Herb. Hongkong, *Herb. Copeland 2314,* frond, × 5.
4. The same specimen, venulation, × 75.
5. The same specimen, detail of structure, × 400.
6. The same specimen, sorus, × 15.

PLATE 25

FIG. 1. *Griffith 151,* in Gray Herb. ex Herb. Kew, possible cotype of *D. plicatum,* segment, showing venulation, × 75.

2. The same specimen, sorus, × 15.

FIG. 3. *Trichomanes insigne. G. Mann, U. S. Nat. Herb. 329769,* sorus, × 15.

4. *Rosenstock, Fil. Chinenses 42,* from Pinfa, sorus and venulation, × 15.
5. *G. Mann, Herb. Univ. Calif. 380969,* from Cachor, venulation, × 75.
6. The same specimen, sorus, × 15.

PLATE 26

FIG. 1. *Hooker and Thomson, Herb. Univ. Calif. 267642,* venulation, × 75.

2. The same specimen, sorus, × 15.
3. *G. Mann, Herb. Univ. Calif. 267023,* venulation, × 75.
4. The same specimen, sorus, × 15.
5. *G. Mann,* Jainta Hills, *U. S. Nat. Herb. 329770,* frond, × 1.
6. The same specimen, venulation, × 75.
7. The same specimen, sorus, × 15.

PLATE 27

FIG. 1. *Trichomanes Makinoi.* Topotype or cotype, ex Herb. Hongkong, frond, × 3.

2. The same specimen, sorus, × 25.

PLATE 28

FIG. 1. *Trichomanes sublimbatum.* Rosenstock, *Fil. Jav. Orient. 67* in Herb. Copeland, frond, × 3.

2. The same specimen, detail of structure, × 400.
3. *Trichomanes henzaianum.* Cotype (?), in Gray Herb., frond, × 5.
4. The same specimen, venulation, × 60.

PLATE 29

FIG. 1. *Trichomanes beccarianum.* Type fragment, × 5.

FIGS. 2 to 7. Mindanao specimens, *Clemens,* in Herb. Copeland, fronds, × 5.

FIG. 8. The same collection, venulation, × 60.

9. Cotype of *Trichomanes minutissimum,* in Herb. Bur. Sci., frond, × 10.
10. The same specimen, sorus, × 15.
11. The same specimen, detail of structure, × 400.

PLATE 30

FIGS. 1 and 2. *Trichomanes Motleyi.* Cotype, in Gray Herb., fronds, × 5.

FIG. 3. The same collection, detail of structure, × 60.

4. The same collection, sorus, × 5.

FIGS. 5 and 6. *Trichomanes cultratum.* Cotype, in Gray Herb., fronds, × 5.

FIG. 7. The same collection, venulation, × 60.

PLATE 31

FIGS. 1 to 4. *Trichomanes omphalodes.* Cotype, in Gray Herb., fronds, × 5.

FIG. 5. The same collection, structure, × 60.
6. The same collection, sori, in end-view, × 5.
7. *Trichomanes montanum, U. S. Nat. Herb. 817008,* frond, × 2.5.
8. The same specimen, sorus, × 15.

PLATE 32

FIG. 1. *Trichomanes exiguum. Beckett,* in Gray Herb., frond, × 5.
2. The same specimen, structure, × 60.
FIGS. 3 and 4. *Trichomanes Wallii.* Ex Herb. Wm. Ferguson, in Gray Herb., fronds, × 5.
FIG. 5. The same collection, structure, × 60.
6. *Trichomanes cuspidatum. U. S. Nat. Herb. 593139,* frond, × 3.
7. The same specimen, sorus, × 15.

PLATE 33

FIG. 1. *Trichomanes bimarginatum.* Cotype, *C. P. 2986,* in Gray Herb., frond, × 5.
2. The same species. Samoa specimen, *Powell,* in Gray Herb., frond, × 5.
3. Fiji specimen, *Brackenridge,* in U. S. Nat. Herb., venulation, × 60.
4. The same specimen, sori, × 5.
FIGS. 5 and 6. *Trichomanes craspedoneuron.* Type, *U. S. Nat. Herb. 593183,* fronds, × 5.
FIG. 7. The same collection, detail of structure, × 400.
8. The same collection, sorus, × 15.

PLATE 34

FIG. 1. *Trichomanes mindorense.* Cotype, in Herb. Bur. Sci., fronds, × 5.
2. The same specimen, detail of structure, × 60.
FIGS. 3 and 4. *Trichomanes erosum. O. F. Cook 506 (U. S. Nat. Herb. 946426),* fronds, × 5.
FIG. 5. The same collection, detail of structure, × 400.
6. The same collection, sorus, × 15.

PLATE 35

FIG. 1. *Trichomanes radicans (T. japonicum). Stanford, U. S. Nat. Herb. 291511,* detail of structure, × 400.
2. The same specimen, sorus, × 15.
3. *Trichomanes cyrtotheca. Hillebrand, Herb. Univ. Calif. 398318,* pinna, × 5.
4. The same specimen, sorus, × 15.

PLATE 36

FIG. 1. *Trichomanes davallioides.* Specimen collected by Gaudichaud, in Herb. Bur. Sci., plant, scale indicated.
2. The same specimen, sorus, × 15.

PLATE 37

Trichomanes cyrtotheca. Specimen collected by Hillebrand, ex Herb. Berlin.

PLATE 38

FIG. 1. *Trichomanes maximum. Herb. Bogor. 108874*, part of pinna, × 5.
2. The same specimen, detail of structure, × 160.
3. The same specimen, sorus, × 15.
4. *Trichomanes maximum.* From Tahiti, *Grant 3625* (*Herb. Univ. Calif. 437783*), tip of pinna, × 40.
5. *Trichomanes aphlebioides. King, Herb. Copeland 12814*, small pinna, × 5.
6. The same specimen, tip of pinna, × 40.
7. The same specimen, detail of structure, × 160.
8. *Trichomanes aphlebioides.* Cotype, in Herb. Univ. Calif., sorus, × 15.

PLATE 39

FIG. 1. *Trichomanes superbum. Foxworthy*, from Sarawak, Herb. Bur. Sci., end of pinna, × 5.
2. The same specimen, detail of structure, × 400.
3. The same specimen, sorus, × 15.
4. Type fragment of *Trichomanes ignobile*, juvenile frond, × 2.
5. The same specimen, detail of structure, × 400.

PLATE 40

FIG. 1. *Trichomanes grande.* Type, in Herb. Copeland, portion of pinna, × 5.
2. The same specimen, tip of segment, × 40.
3. The same specimen, detail of structure, × 400.
4. The same specimen, sorus, × 15.
5. *Trichomanes intermedium.* Cotype, *U. S. Nat. Herb. 51161*, sorus, × 15.

PLATE 41

FIG. 1. *Trichomanes blepharistomum.* Type, portion of pinna, × 5.
2. The same specimen, tip of segment, × 40.
3. The same specimen, detail of structure, × 400.
4. The same specimen, old sorus, × 15.
5. The same species, *Bur. Sci. 79655*, young sorus, × 15.
6. The same species, a narrowly winged sorus, × 15.

PLATE 42

FIG. 1. *Trichomanes apiifolium.* Cotype, *Herb. Copeland 1965*, sorus, × 15.
2. *Trichomanes bauerianum.* Norfolk Island specimen, *Herb. Univ. Calif. 418050*, sorus, × 15.
3. *Trichomanes polyanthum.* From Huahine, *Grant 5325* (*Herb. Univ. Calif. 437786*), sorus, × 15.
4. *Trichomanes Baldwinii. Heller 2179* (*Herb. Univ. Calif. 150243*), portion of pinna, × 5.
5. The same specimen, detail of structure, × 400.
6. The same specimen, trichome, × 200.
7. The same specimen, sorus, × 15.
8. The same species, *Baldwin, Herb. Univ. Calif. 122648*, sorus, × 15.

PLATE 43

FIG. 1. *Trichomanes obscurum. Palmer and Bryant 500,* from Java (*U. S. Nat. Herb. 651944*), pinnule, × 4.
2. The same specimen, detail of structure, × 400.
3. The same specimen, sorus, × 15.
4. *Trichomanes latipinnum.* Type, in Herb. Copeland, pinnule, × 4.
5. The same specimen, detail of structure, × 400.
6. The same specimen, sorus, × 15.

PLATE 44

FIG. 1. *Trichomanes obscurum* (*T. papillatum*). *Cuming 189* (*Herb. Copeland 2032*), detail of structure, × 400.
2. The same species, *Cuming 134* (*Herb. Copeland 2035*), sorus, × 15.
3. The same species, *Foxworthy 243* (*Herb. Copeland 2156*), from Sarawak, × 5.
4. The same specimen, detail of structure, × 400.
5. The same specimen, sorus, × 15.

PLATE 45

FIG. 1. *Trichomanes dentatum.* Cotype, *Brackenridge,* Tahiti, in U. S. Nat. Herb., pinna.
2. The same specimen, pinnule.

PLATE 46

FIG. 1. *Trichomanes dentatum.* Cotype in U. S. Nat. Herb., tip of pinnule.
2. The same specimen, detail of structure, × 800.
3. The same species, New Caledonia specimen, *Vieillard,* pinnule, × 5.
4. The same specimen, detail of structure, × 800.

PLATE 47

FIG. 1. *Trichomanes elongatum. U. S. Nat. Herb. 817033,* part of pinna, × 4.
2. The same specimen, detail of structure, × 400.
3. *Trichomanes longicollum. Franc 707* (*Herb. Copeland 10874*), part of pinna, × 4.
4. The same specimen, detail of structure, × 400.
5. The same specimen, sorus, × 15.

PLATE 48

FIG. 1. *Trichomanes extravagans.* Type, with scale indicated.
2. The same specimen, pinnule, × 2.
3. The same specimen, sorus, × 15.

PLATE 49

FIG. 1. *Trichomanes cupressoides. Holst 1244* (*U. S. Nat. Herb. 807579*), plant, with scale indicated.
2. The same specimen, part of pinna, × 2.
3. The same specimen, detail of structure, × 200.

PLATE 50

Trichomanes batrachoglossum. Type, in U. S. Nat. Herb., scale indicated.

PLATE 51

FIG. 1. *Trichomanes batrachoglossum.* Type, part of pinna, × 4.
2. The same specimen, detail of structure, × 400.
3. *Trichomanes stylosum. Ayres,* in Mauritius, *U. S. Nat. Herb. 51119,* pinna, × 3.
4. The same specimen, detail of structure, × 400.
5. The same specimen, sorus, × 15.

PLATE 52

FIG. 1. *Trichomanes javanicum.*
2. *Trichomanes asplenioides.*
3. *Trichomanes atrovirens.*
4. *Trichomanes boryanum.*
5. *Trichomanes singaporianum.*

PLATE 53

FIG. 1. *Trichomanes densinervium.* Type.
2. *Trichomanes Kingii.* Type.
3. *Trichomanes acrosorum.* Type.
4. *Trichomanes sumatranum.*

PLATE 54

Trichomanes crassum. Type, in Herb. Bur. Sci., scale indicated.

PLATE 55

FIG. 1. *Trichomanes asplenioides. Bur. Sci. 1581 Weber,* detail of structure, × 400.
2. *Trichomanes atrovirens. Copeland 206,* detail of structure, × 400.
3. *Trichomanes crassum.* Type, detail of structure, × 400.

PLATE 56

FIG. 1. *Trichomanes Cumingii.* Cotype, *Herb. Copeland, 2240,* part of pinna.
2. The same specimen, detail of structure.
3. *Trichomanes strictum. Herb. Univ. Calif. 398322,* detail of structure, × 400.
4. The same specimen, sorus, × 15.

PLATE 57

FIG. 1. *Trichomanes setaceum.* Cotype of *T. Merrillii,* in Herb. Copeland, detail of structure, × 400.
2. *Trichomanes laetum. Vieillard 2139,* in Gray Herb., detail of structure, × 400.
3. *Trichomanes caudatum.* Type, in U. S. Nat. Herb., segment, × 75.
4. The same specimen, detail of structure.
5. The same specimen, sorus.

PLATE 58

FIG. 1. *Trichomanes caudatum.* Type, *U. S. Nat. Herb. 51176.*
2. *Trichomanes flavo-fuscum.* Cotype, in Gray Herb., scale indicated.

PLATE 59

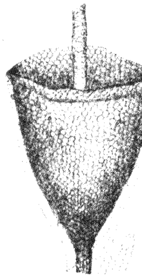
FIG. 1. *Trichomanes compactum.* Type, in Herb. Singapore, type sheet, scale indicated.
2. The same specimen, detail of structure, × 200.
3. The same specimen, sorus, × 15.

PLATE 60

Trichomanes Schlechteri. Cotype, in Herb. Univ. Calif.

PLATE 61

FIG. 1. *Trichomanes Asae-Grayi.* Cotype, *U. S. Nat. Herb. 51163.*
2. *Trichomanes gemmatum.* Cotype, in Gray Herb.



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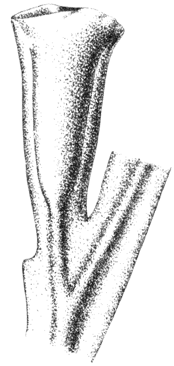

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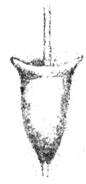

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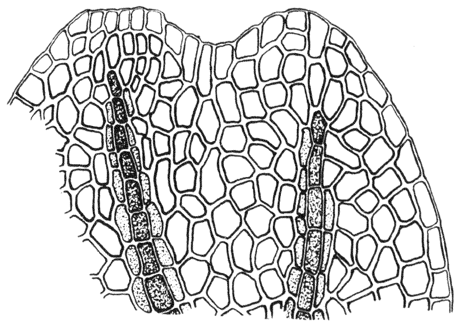

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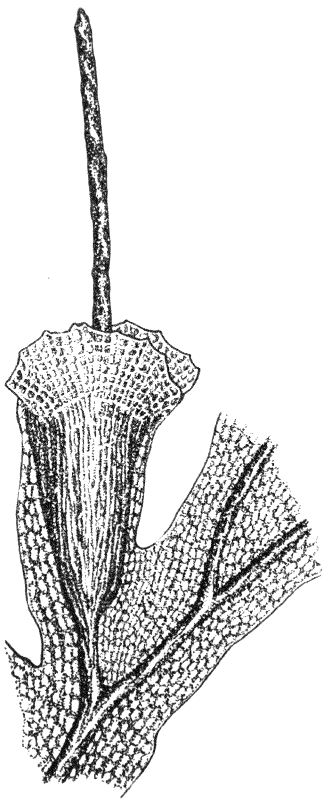

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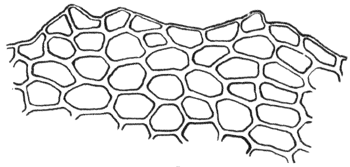

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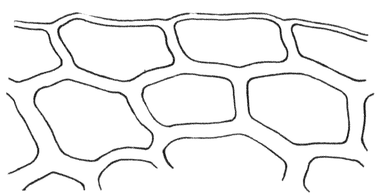

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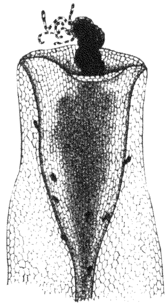
PLATE 1.



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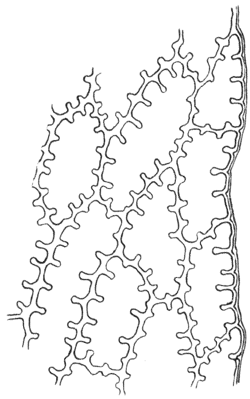

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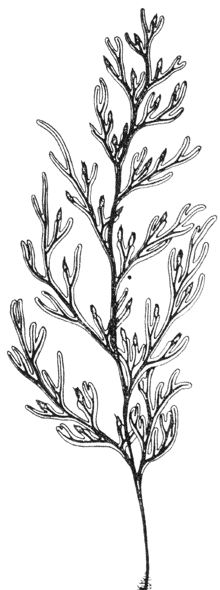

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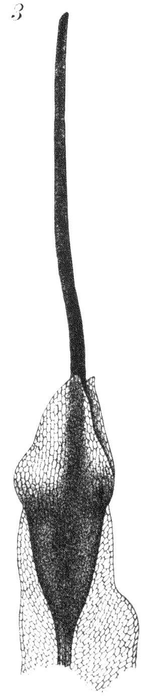

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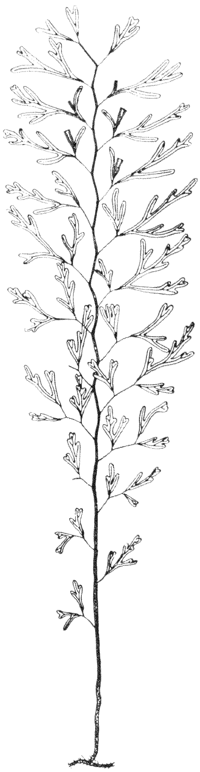
PLATE 2.



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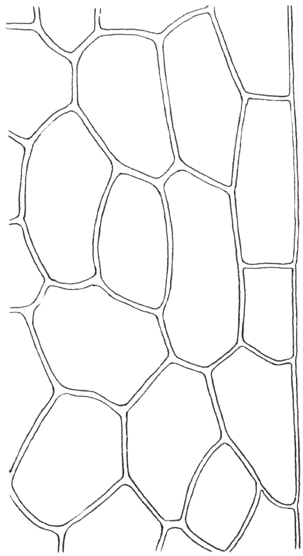

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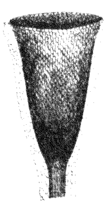

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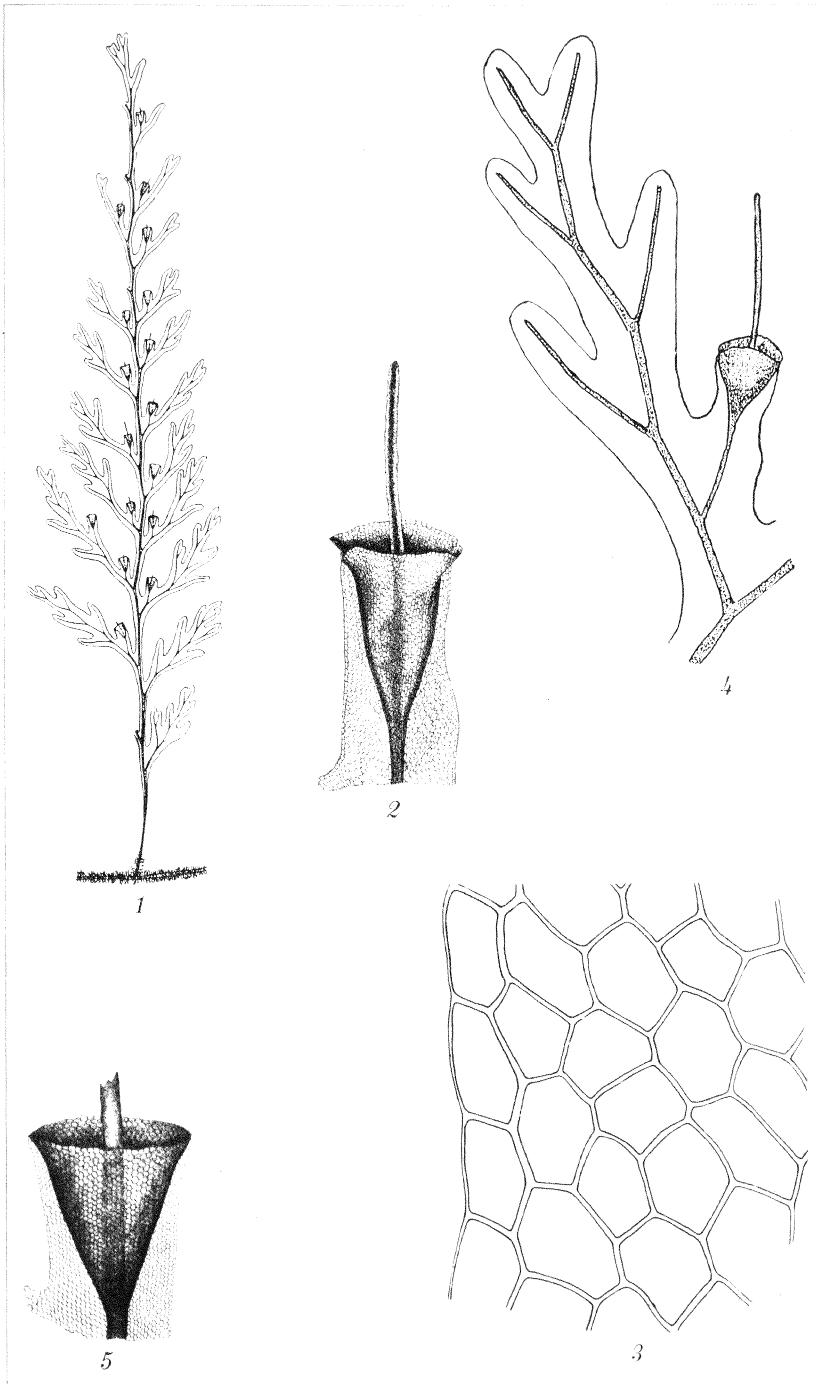

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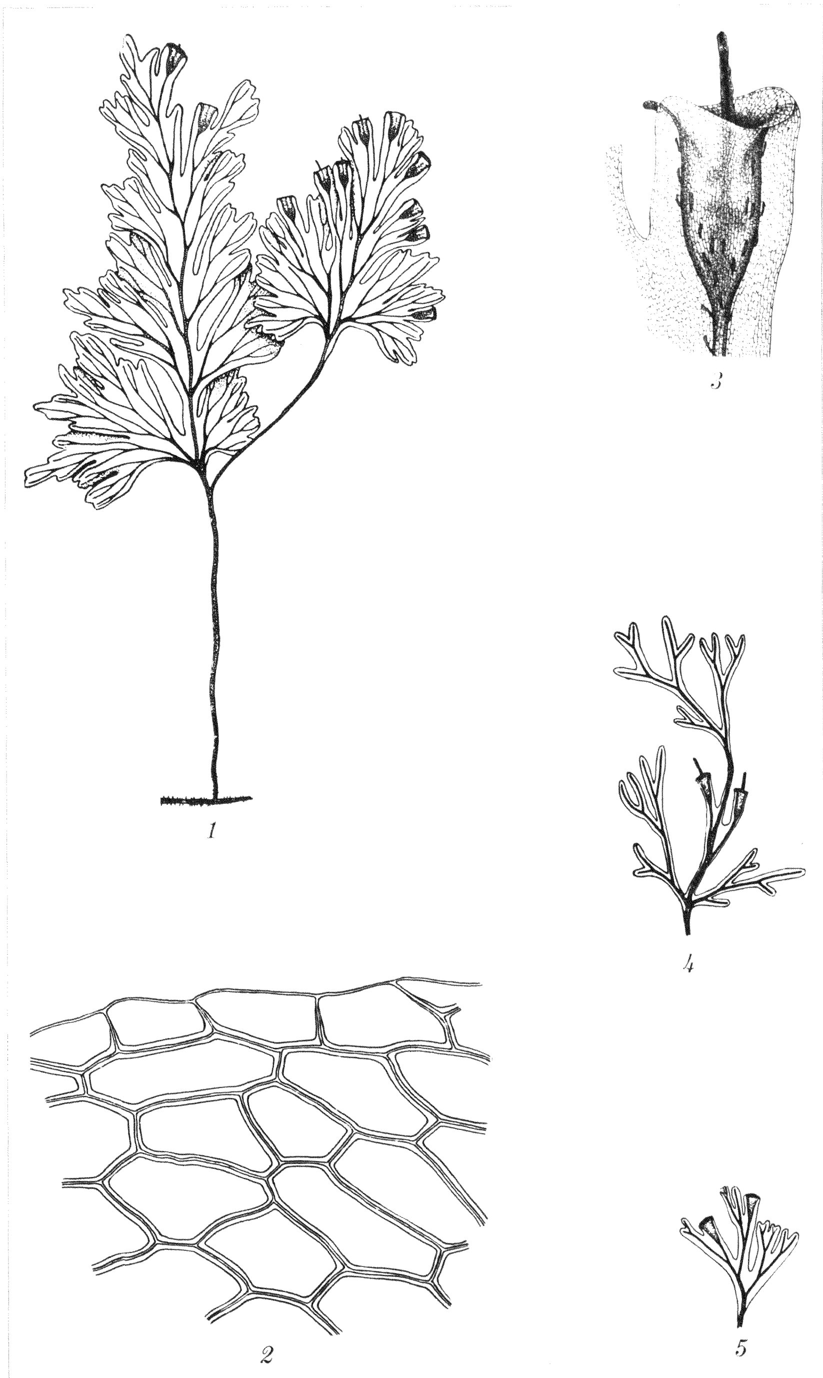

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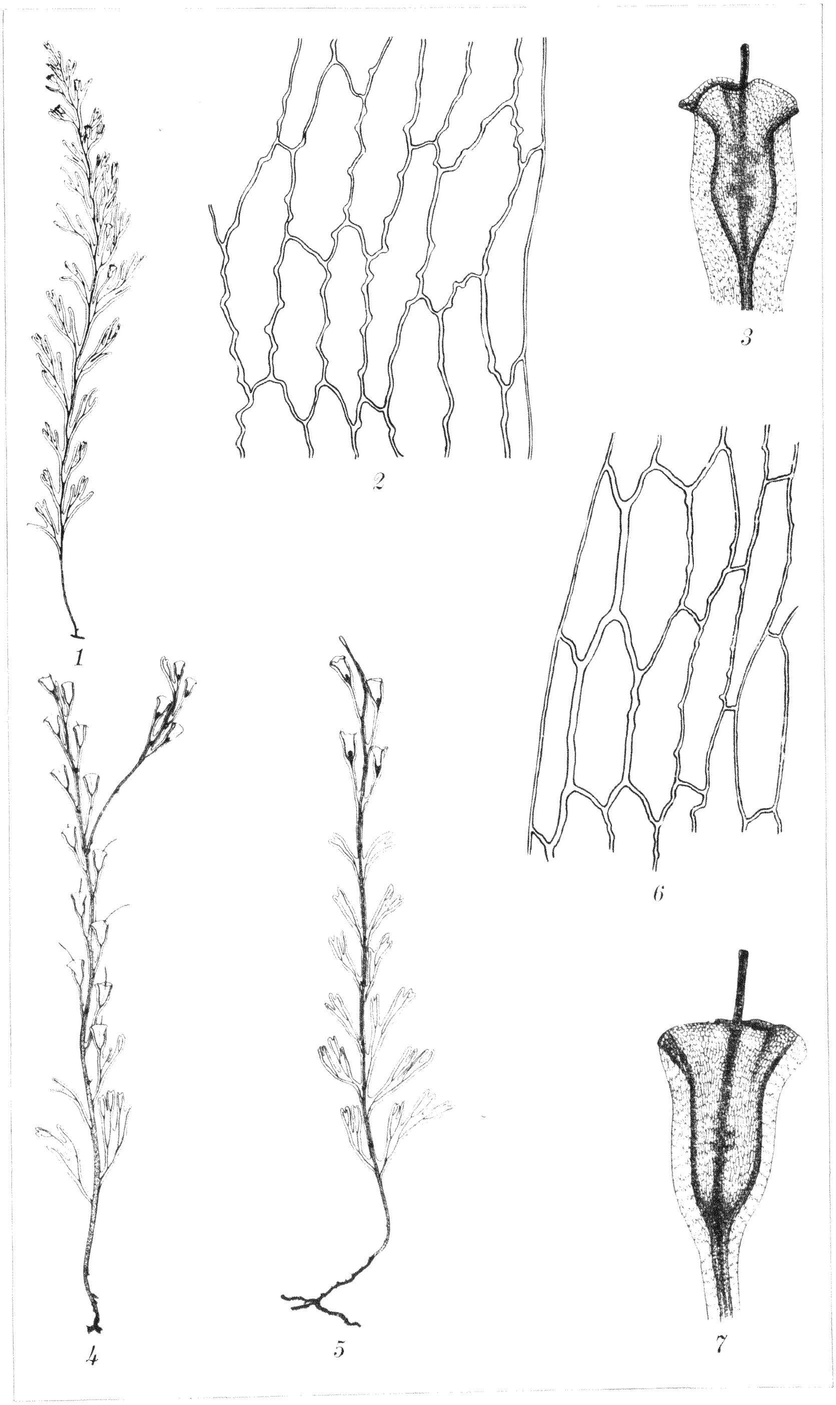
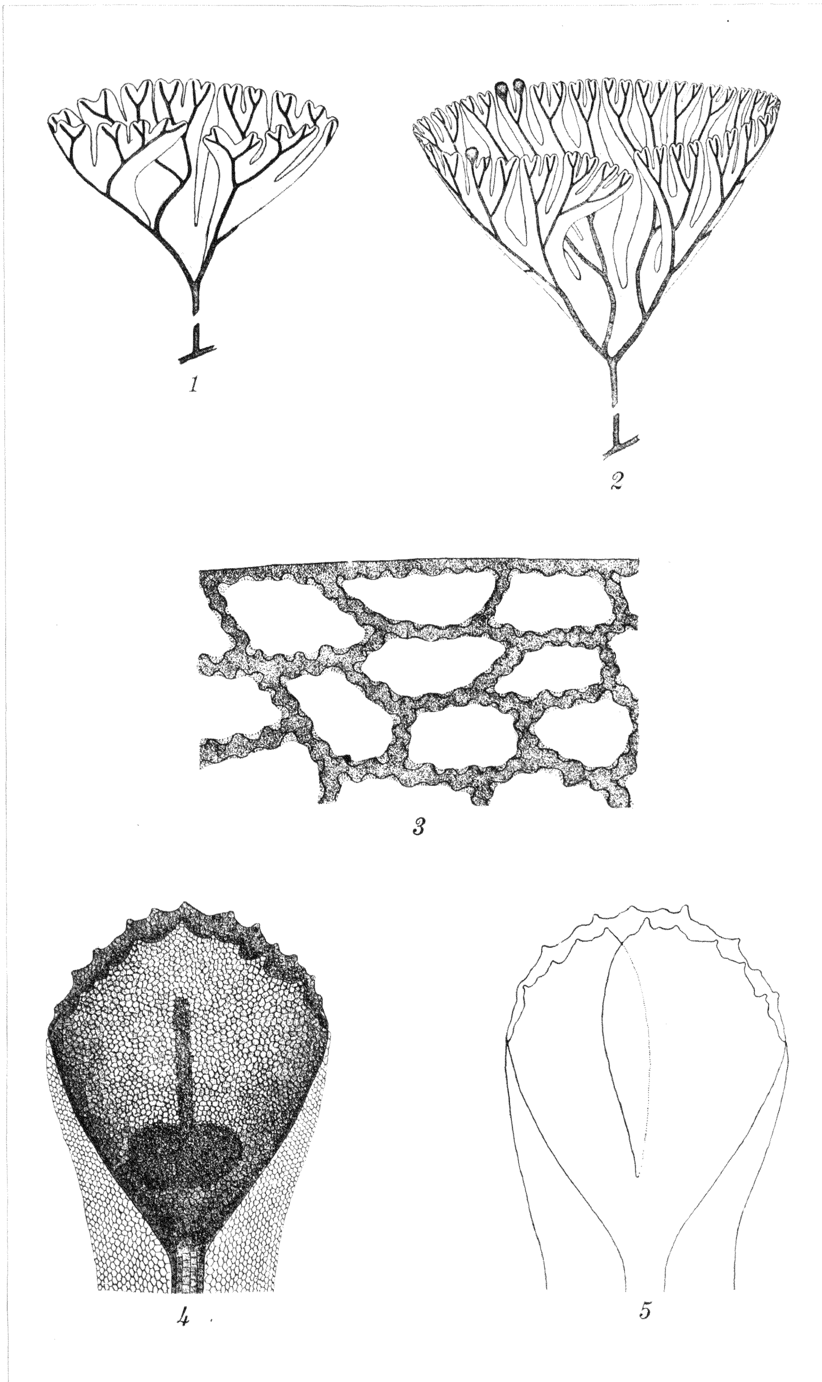


PLATE 6.

PLATE 7.



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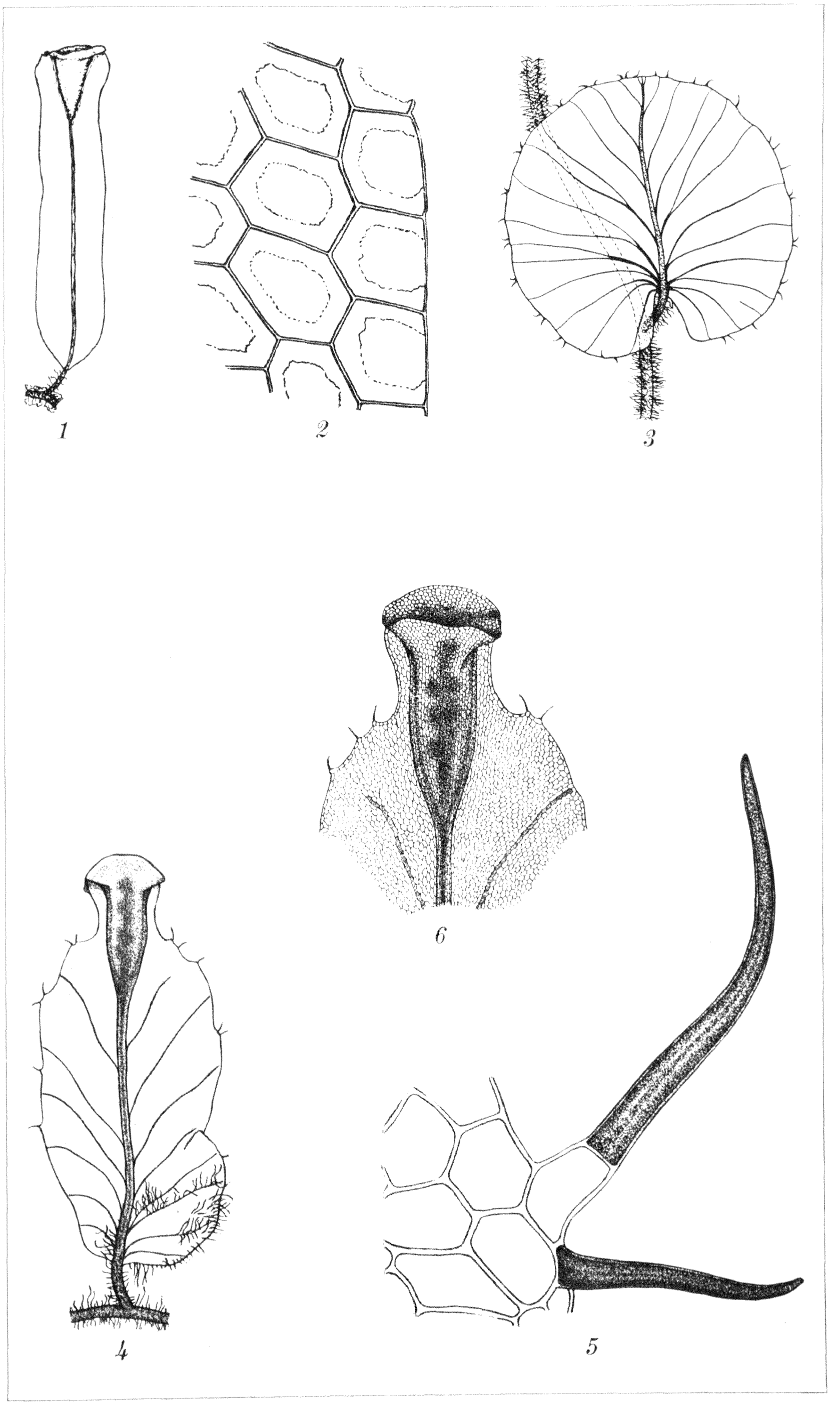

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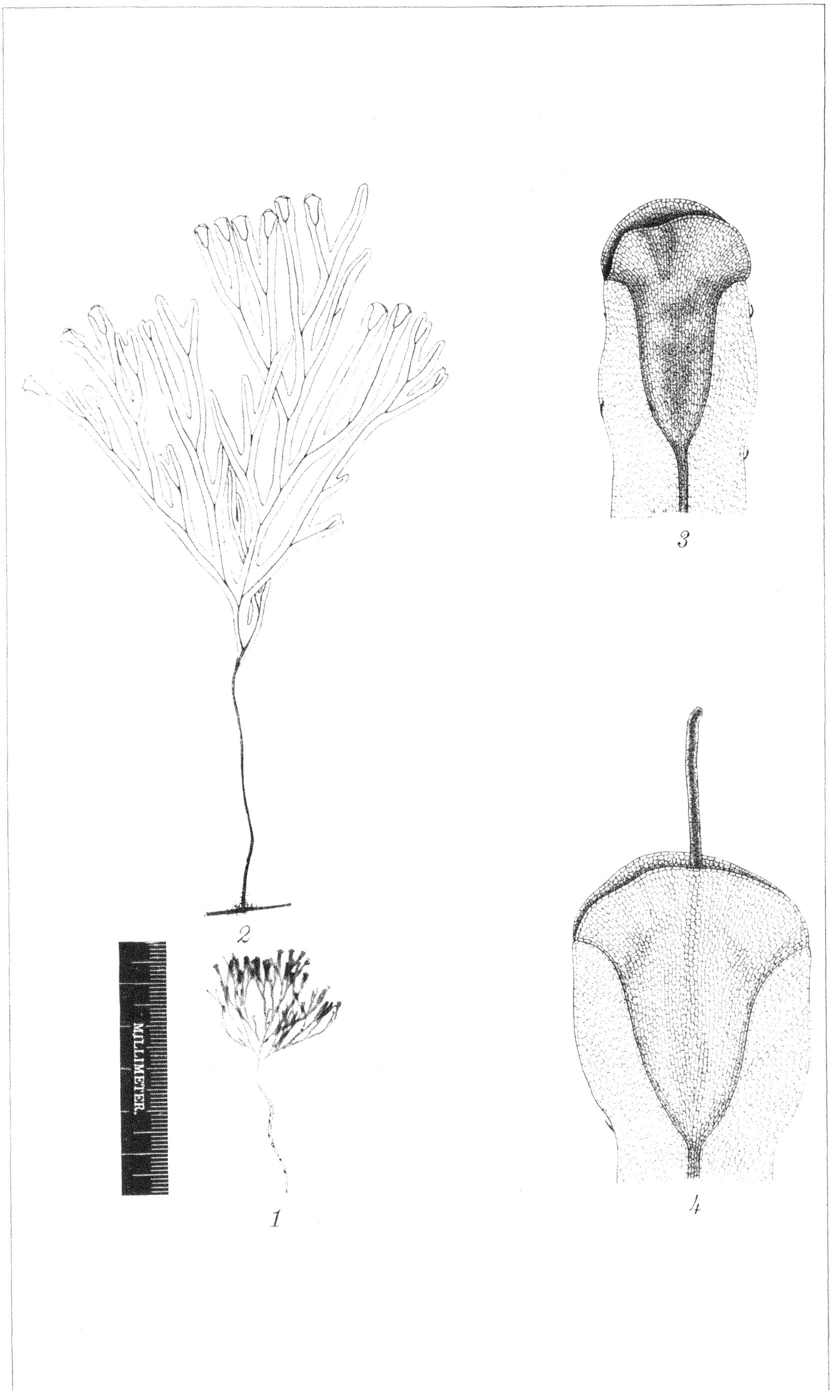

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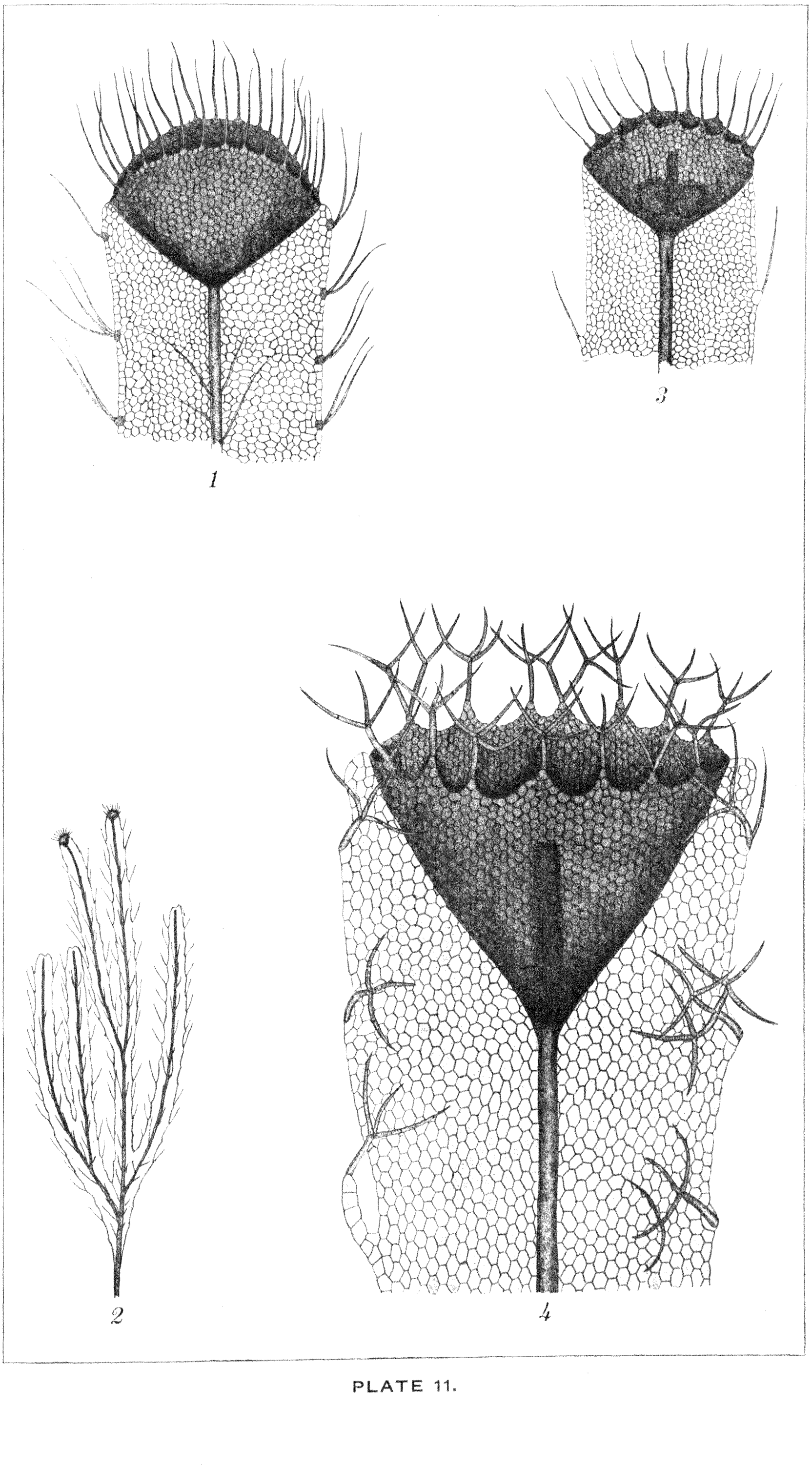

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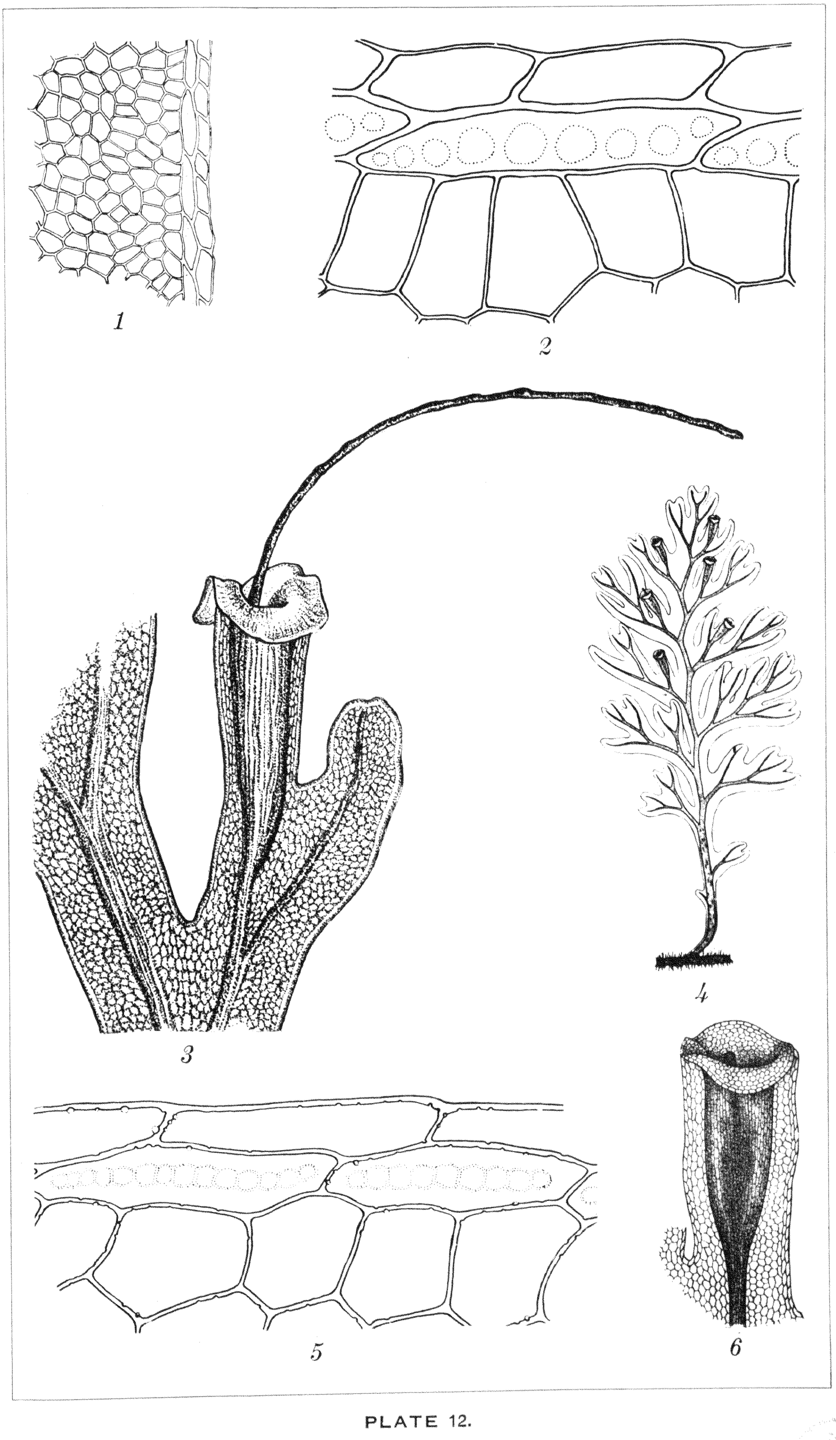

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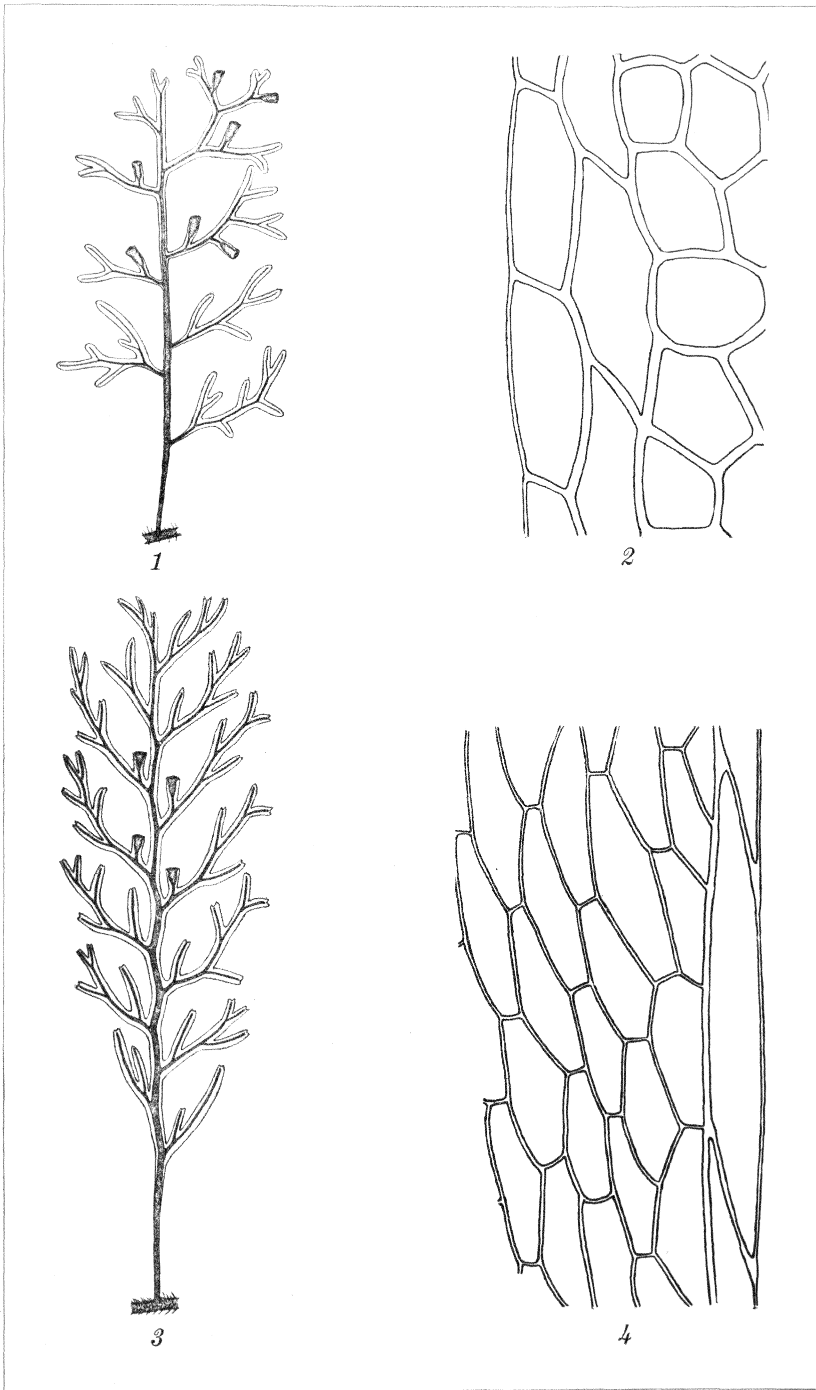

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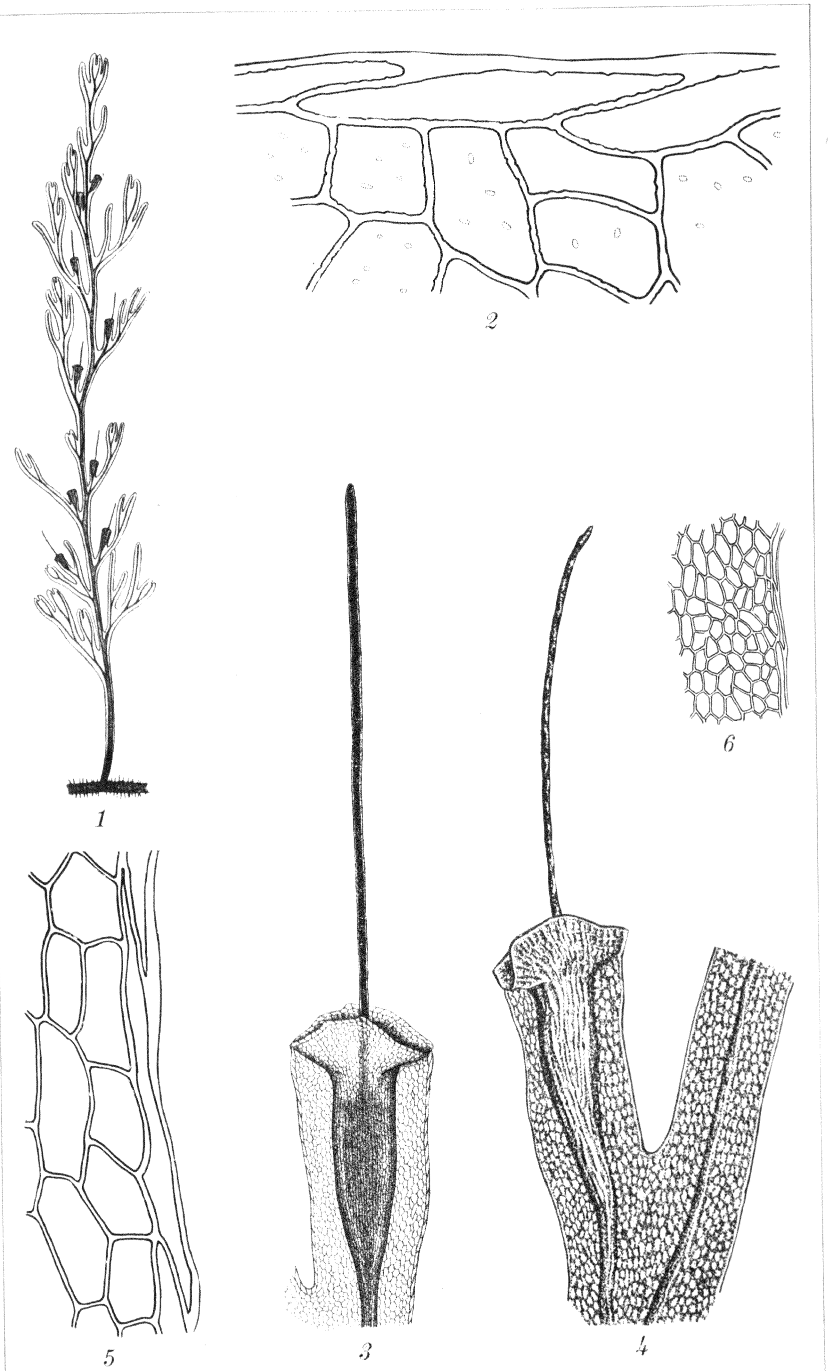

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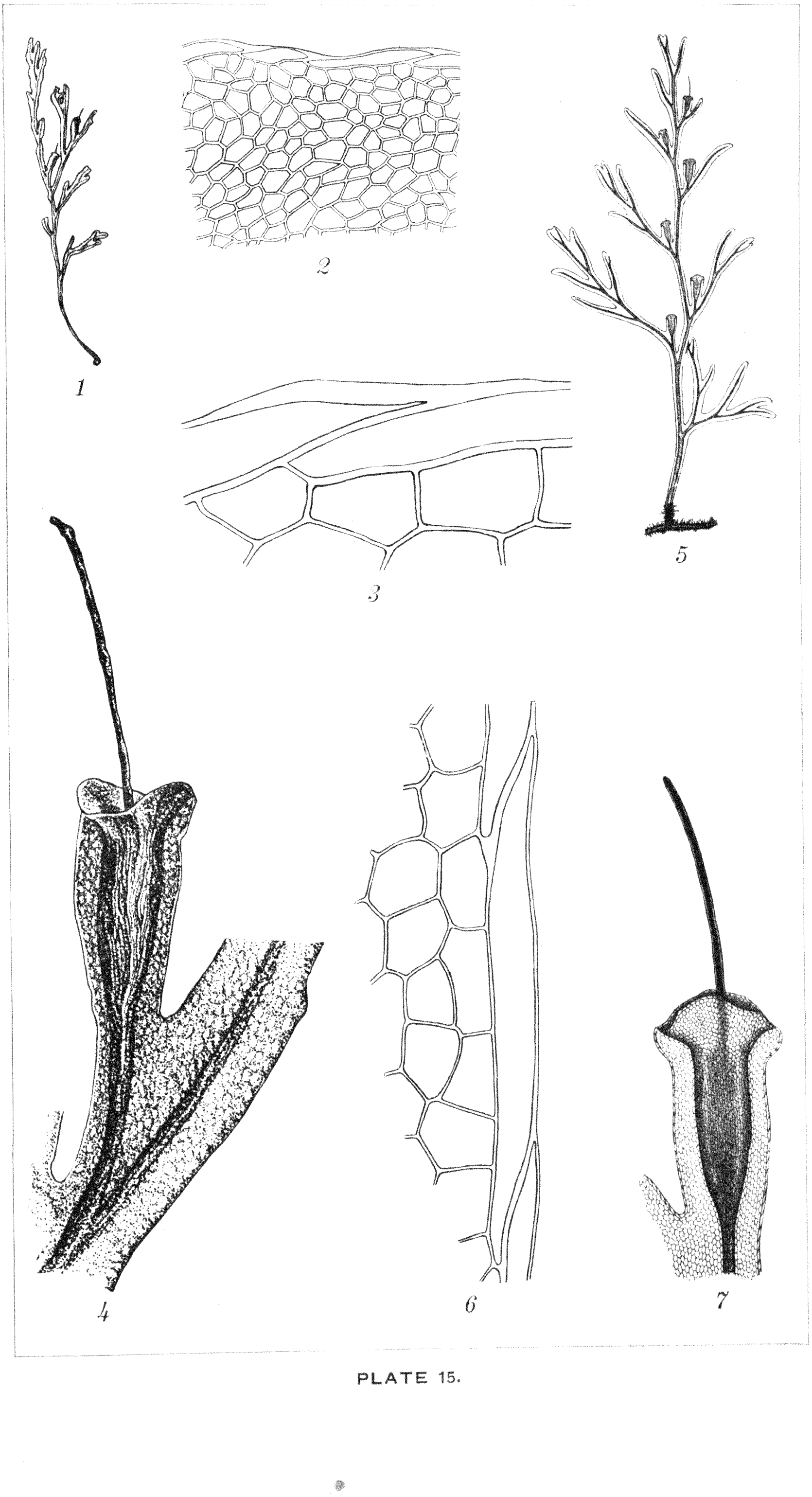

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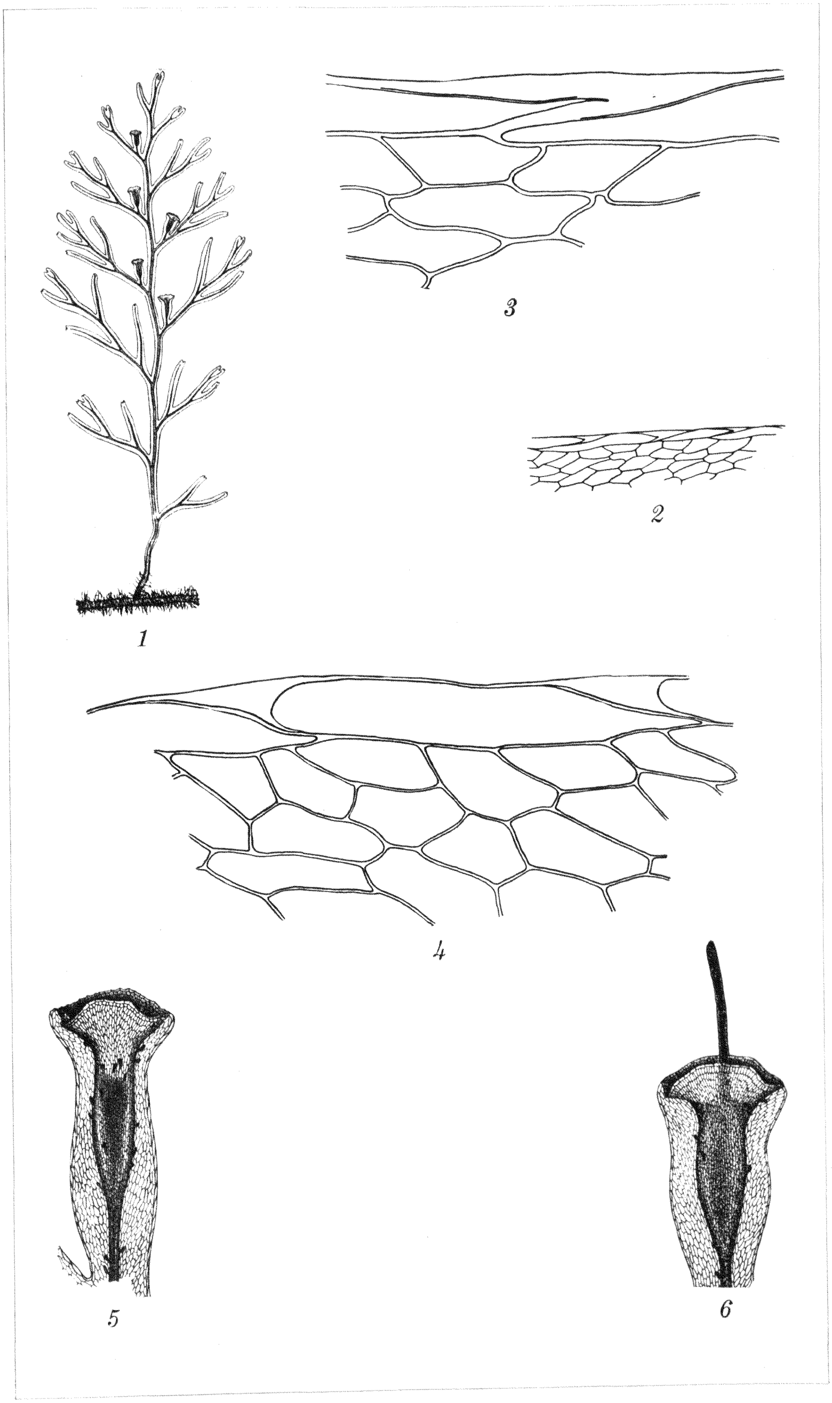

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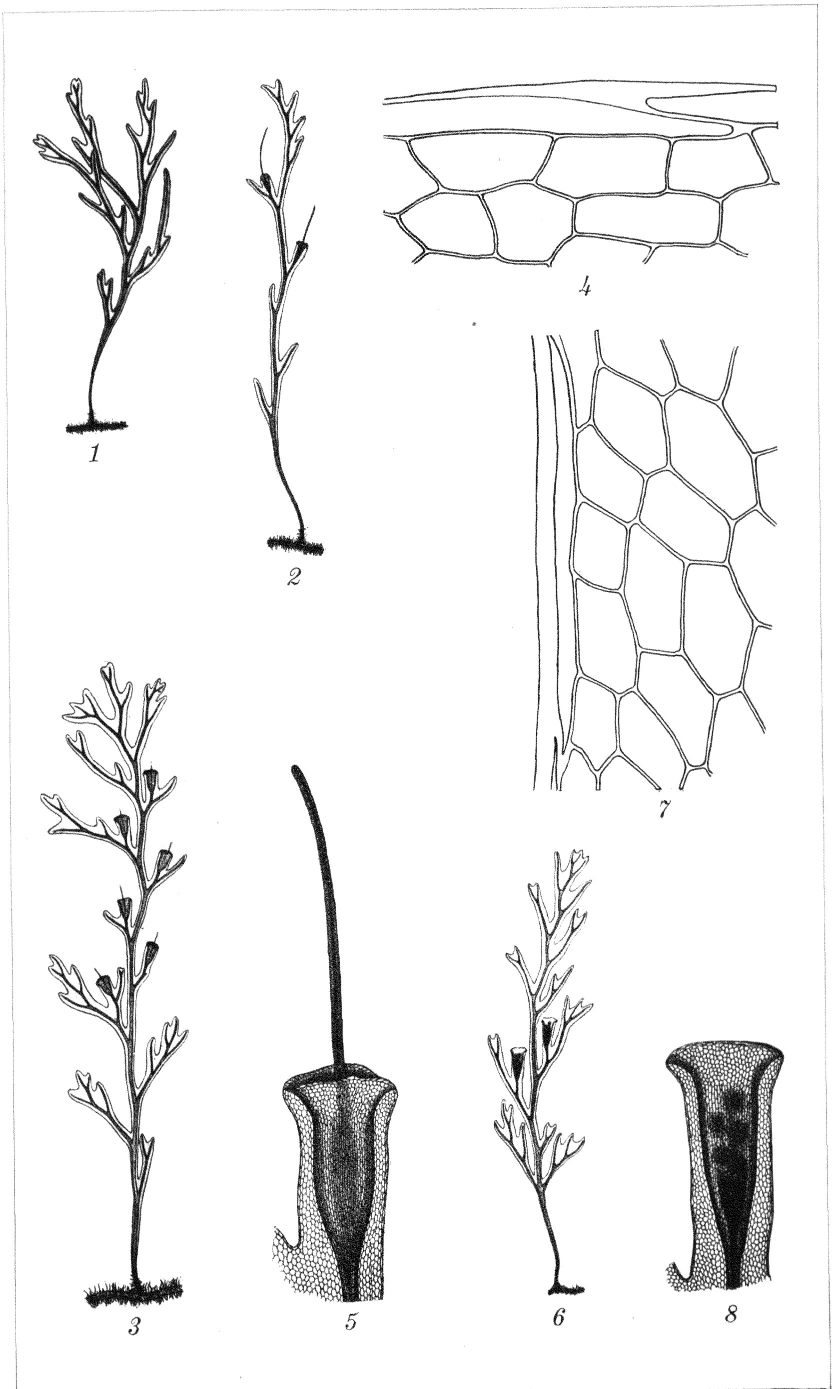

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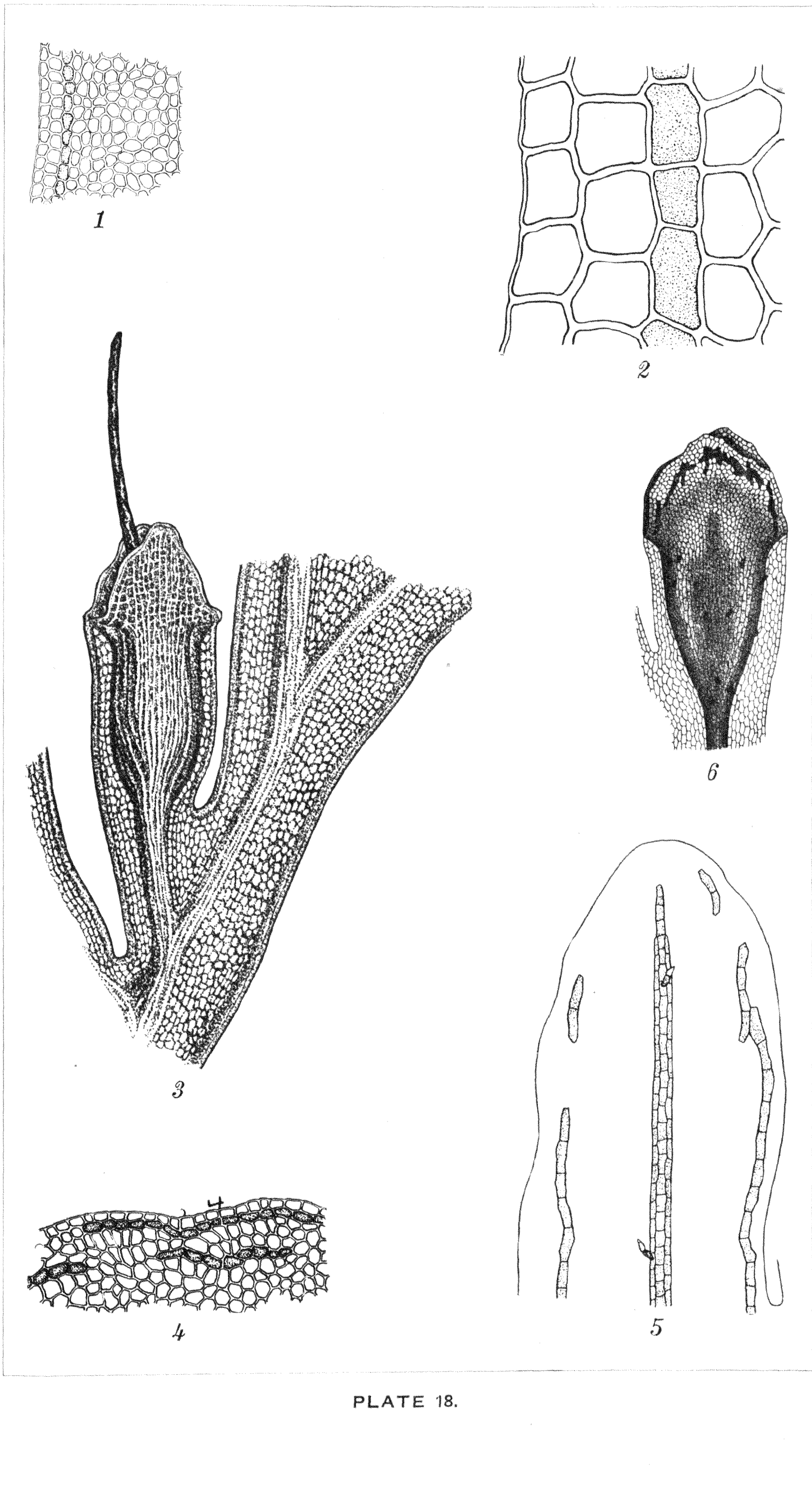
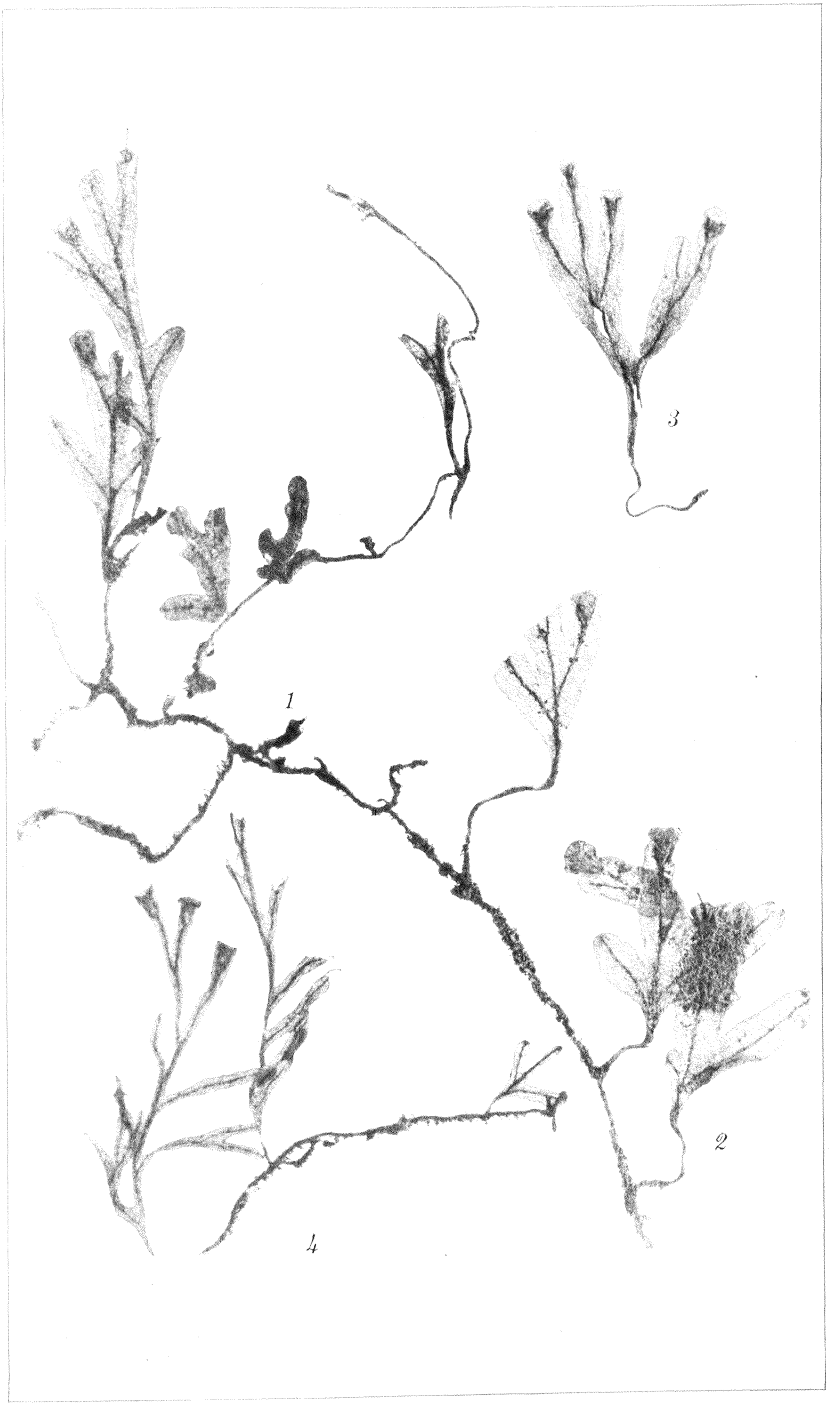


PLATE 18.



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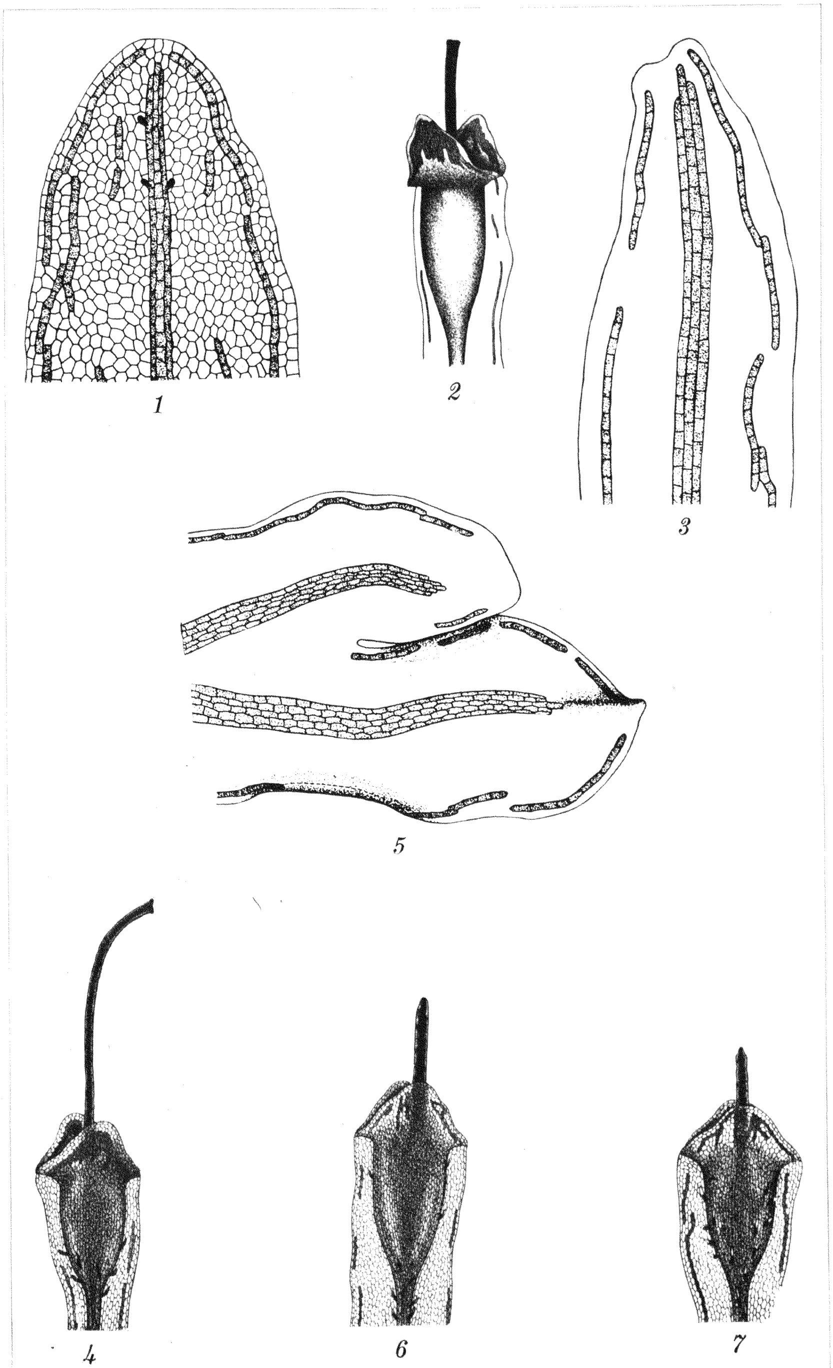


PLATE 20.

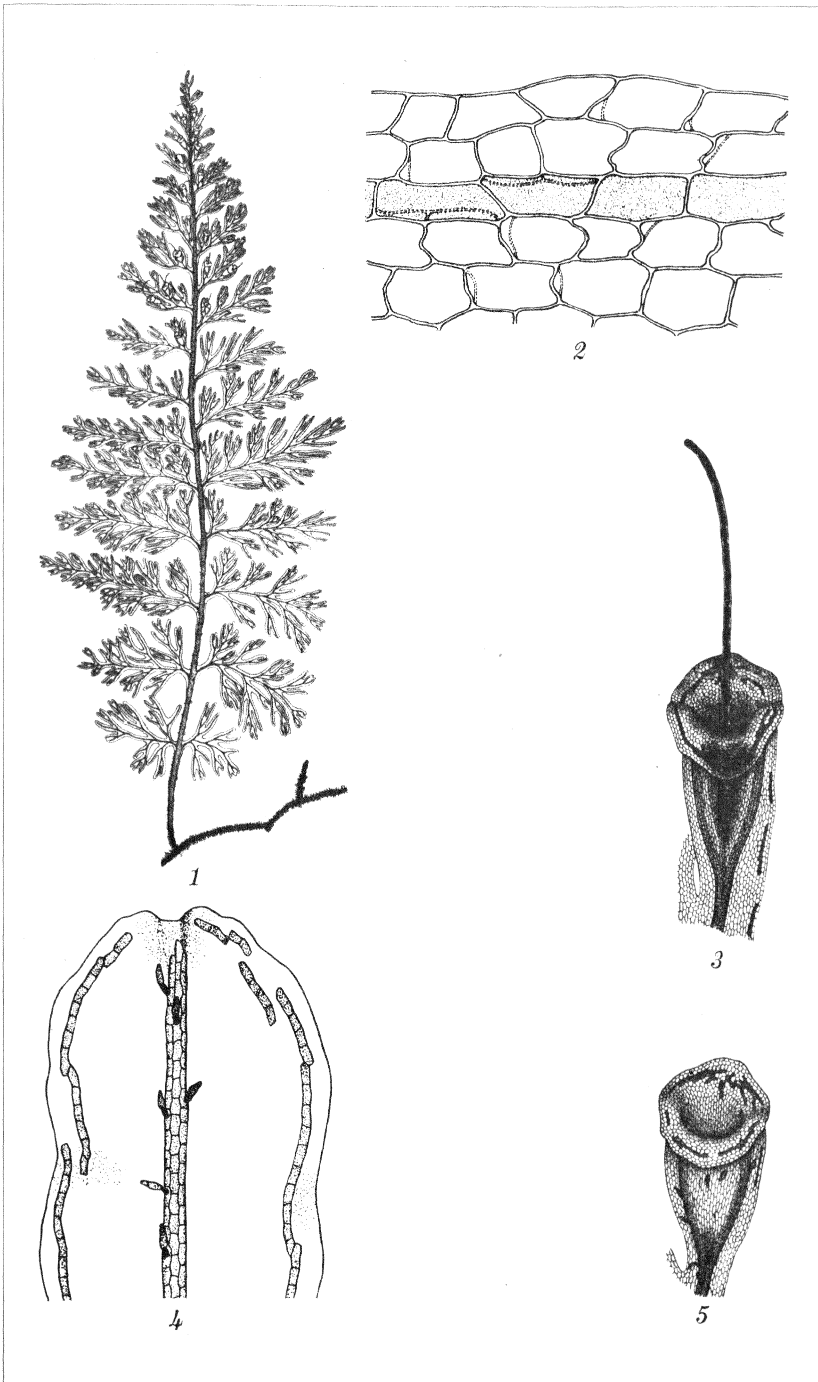


PLATE 21.

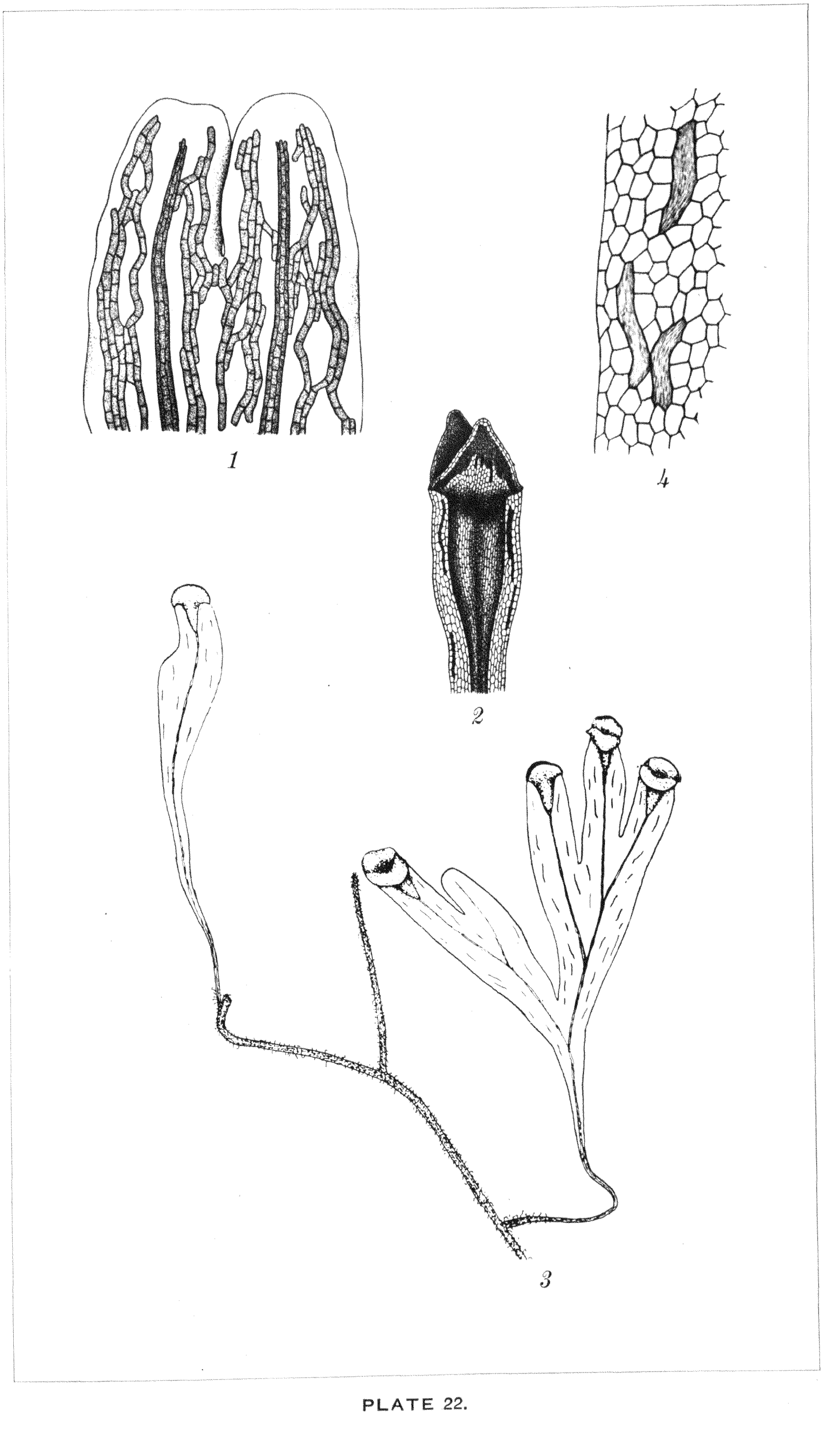
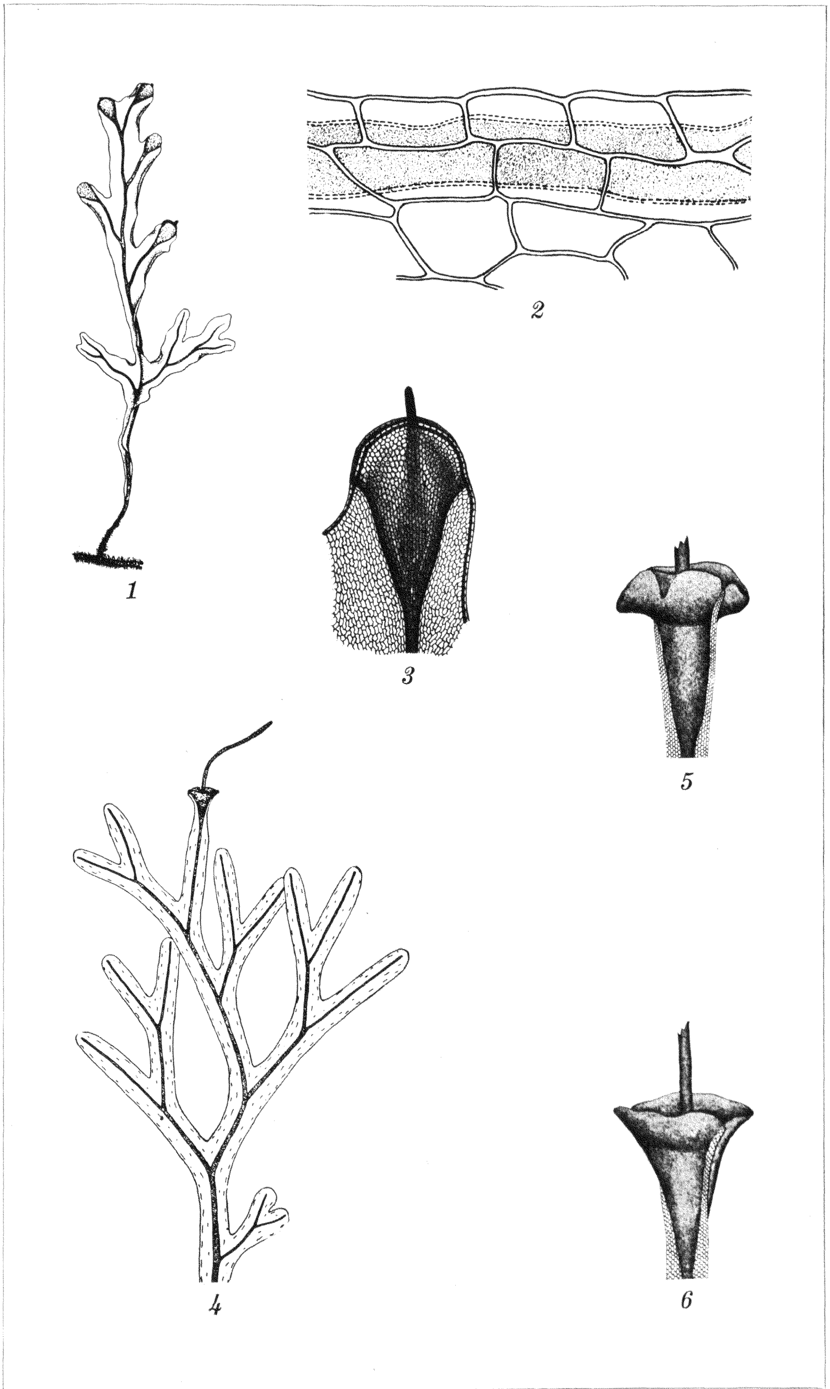


PLATE 22.



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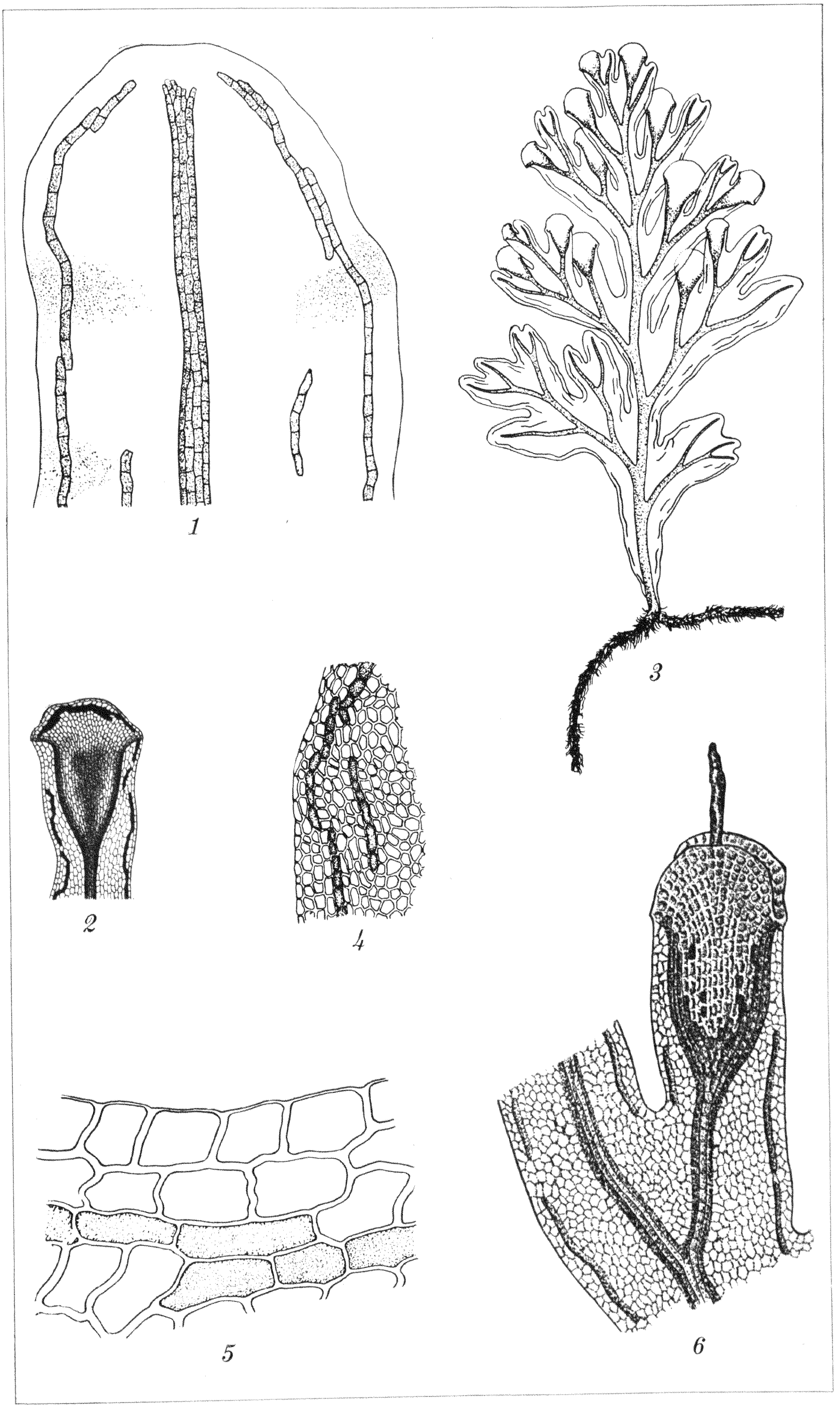

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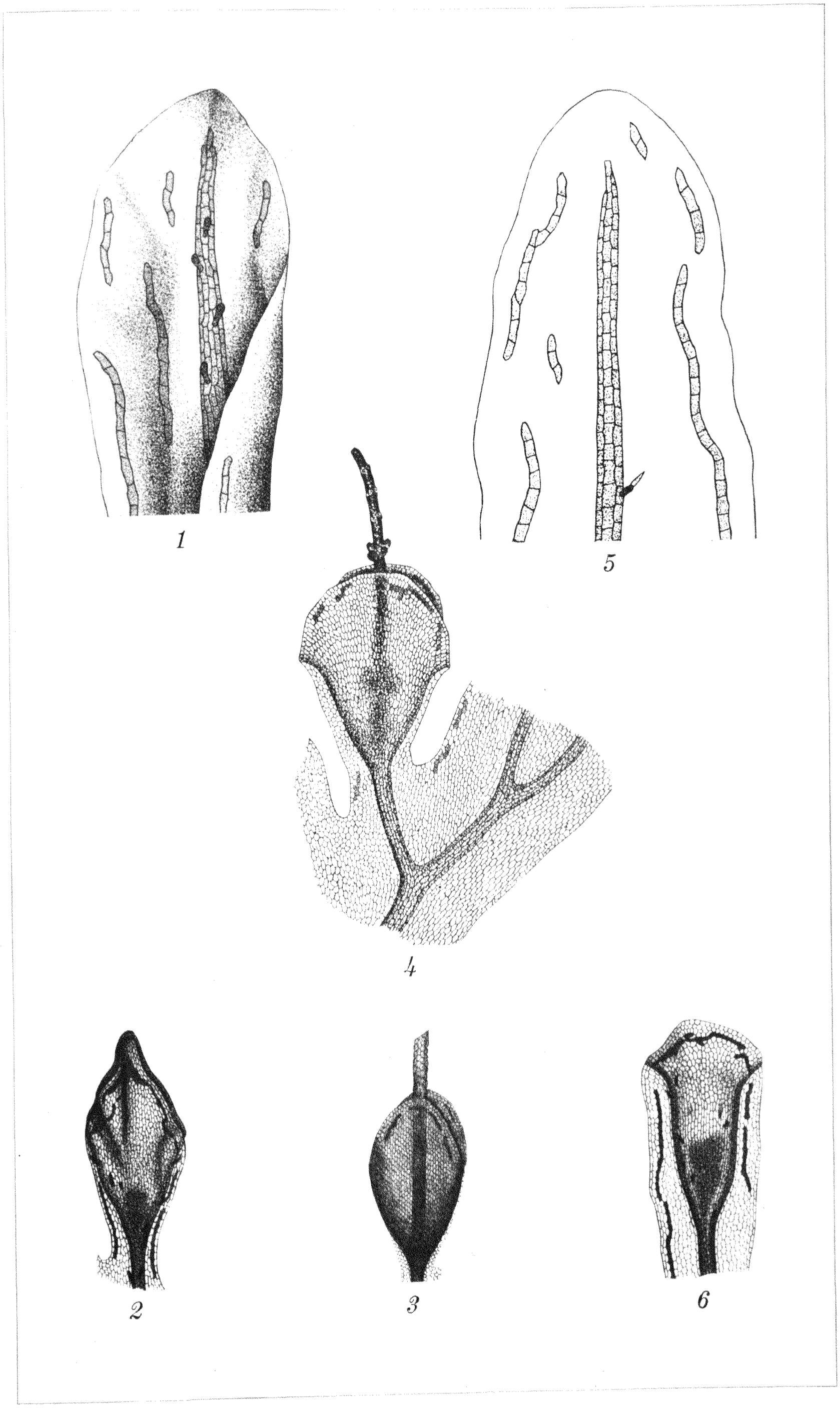

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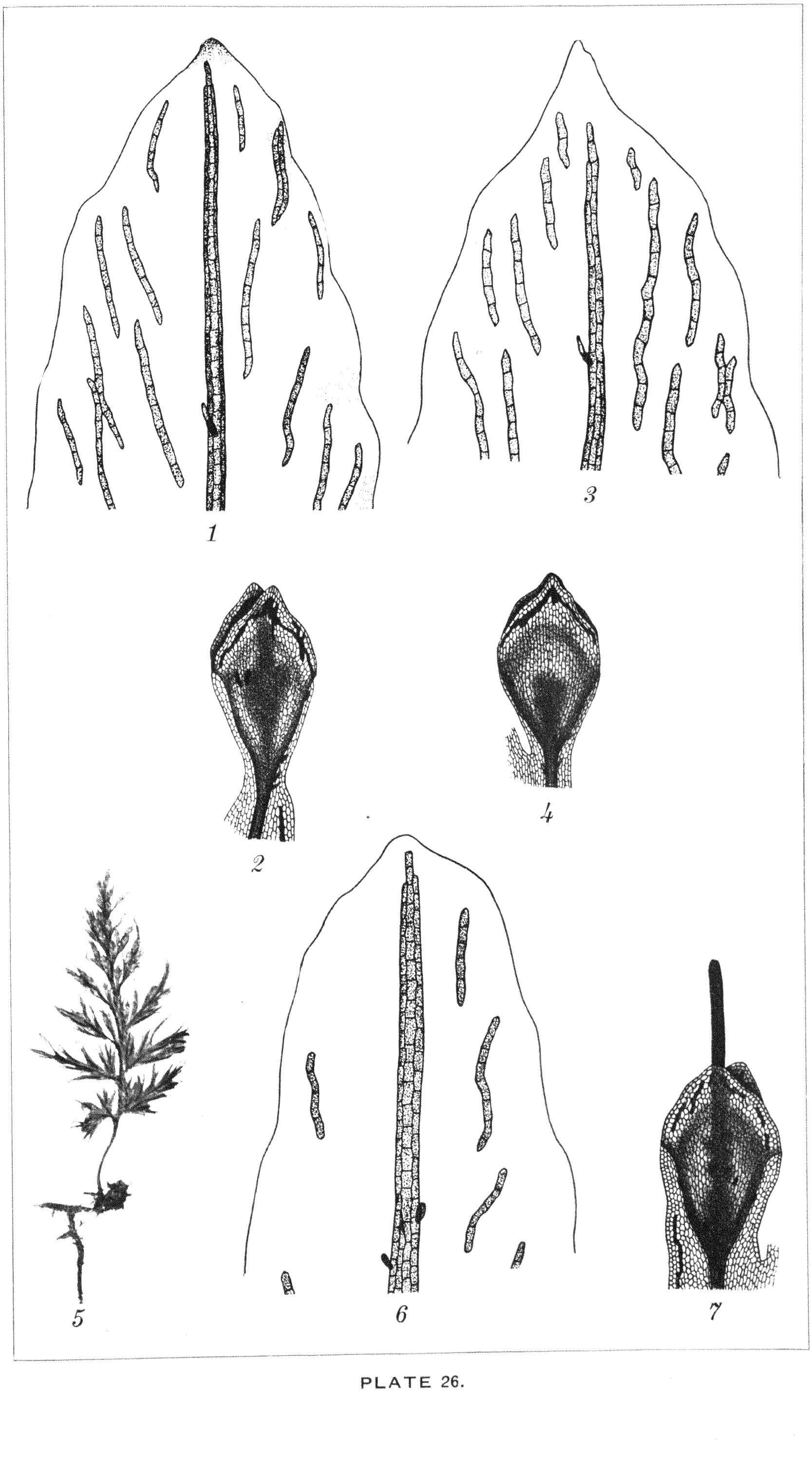

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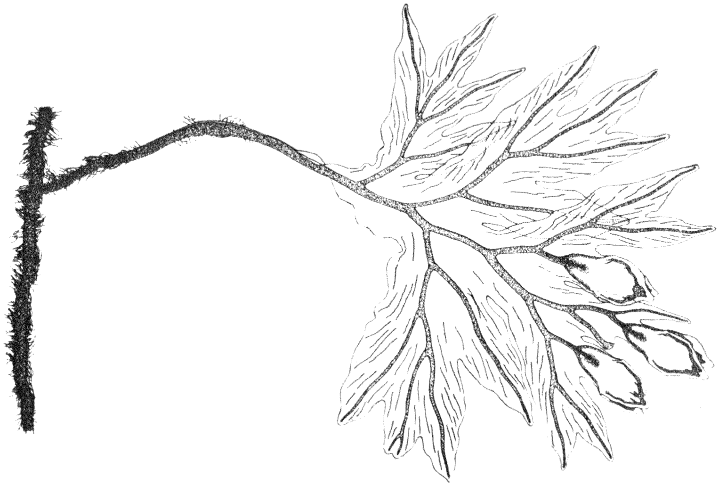

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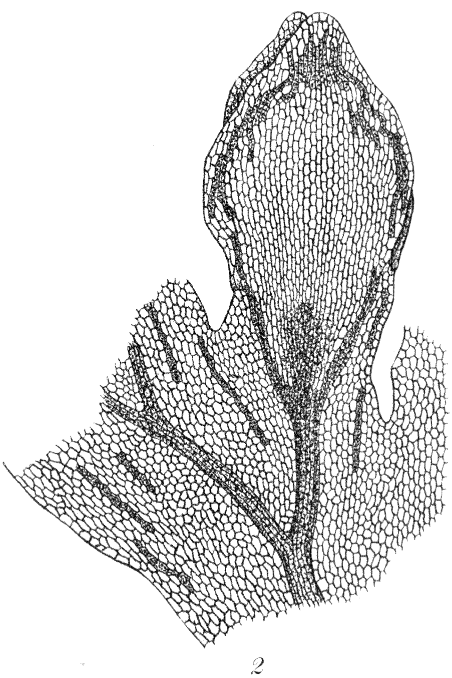

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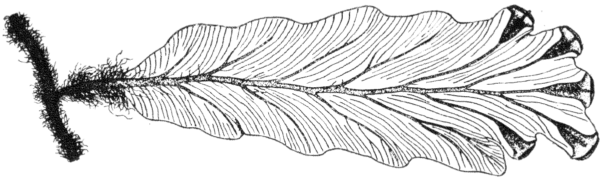
PLATE 27.



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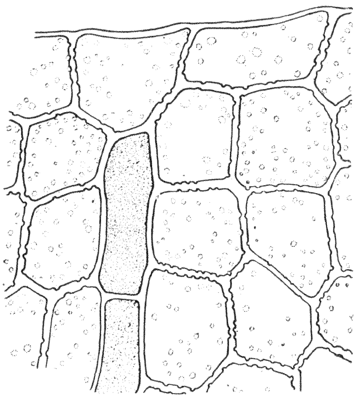

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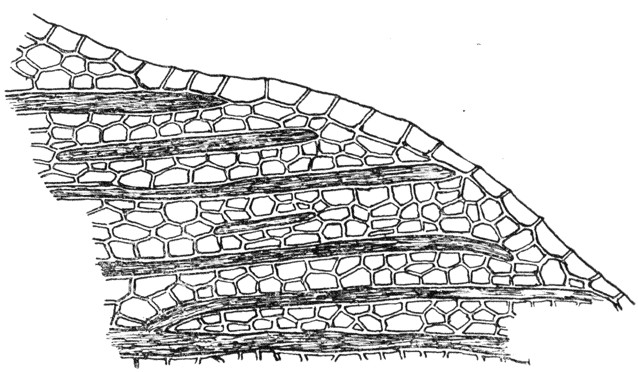

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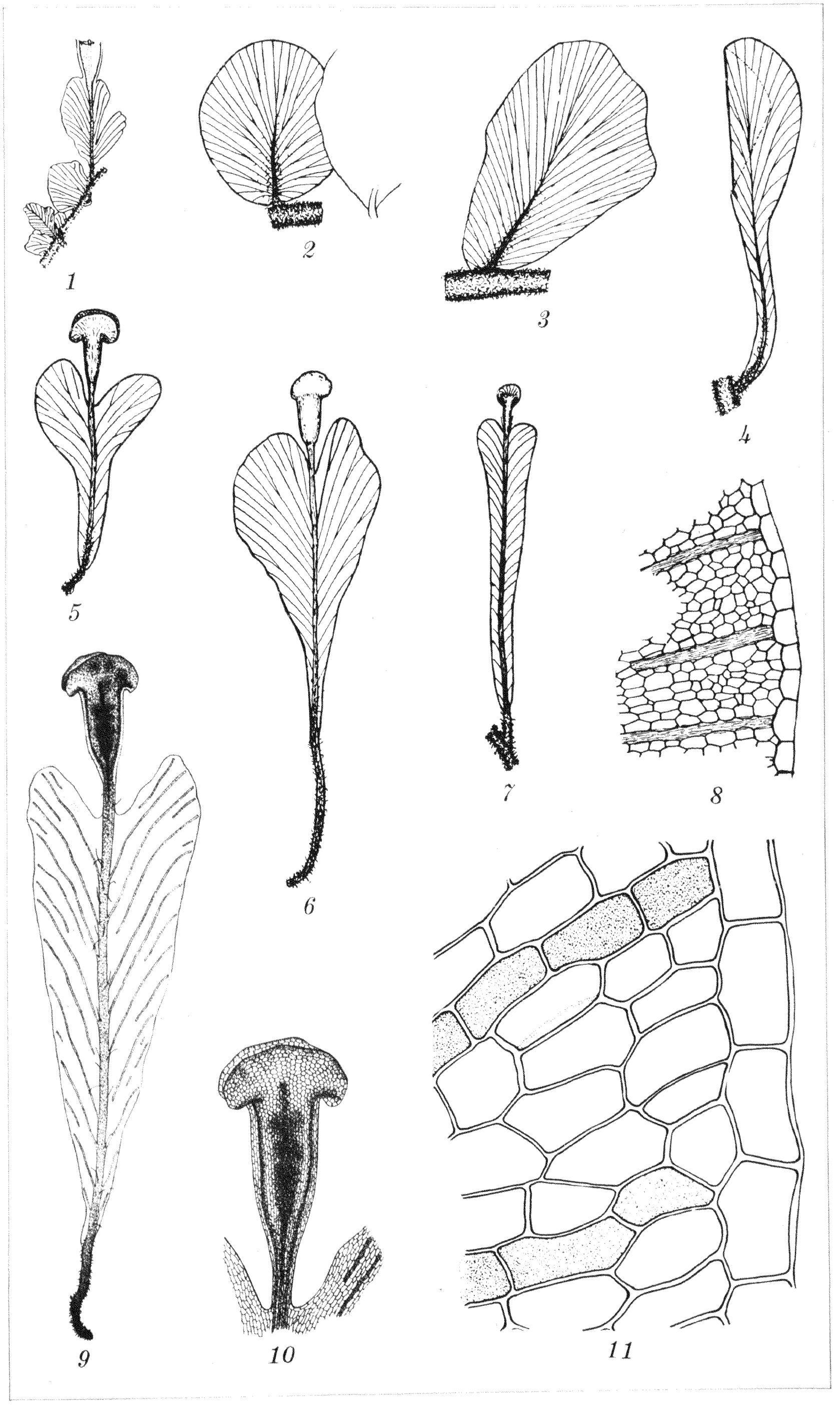
PLATE 28.



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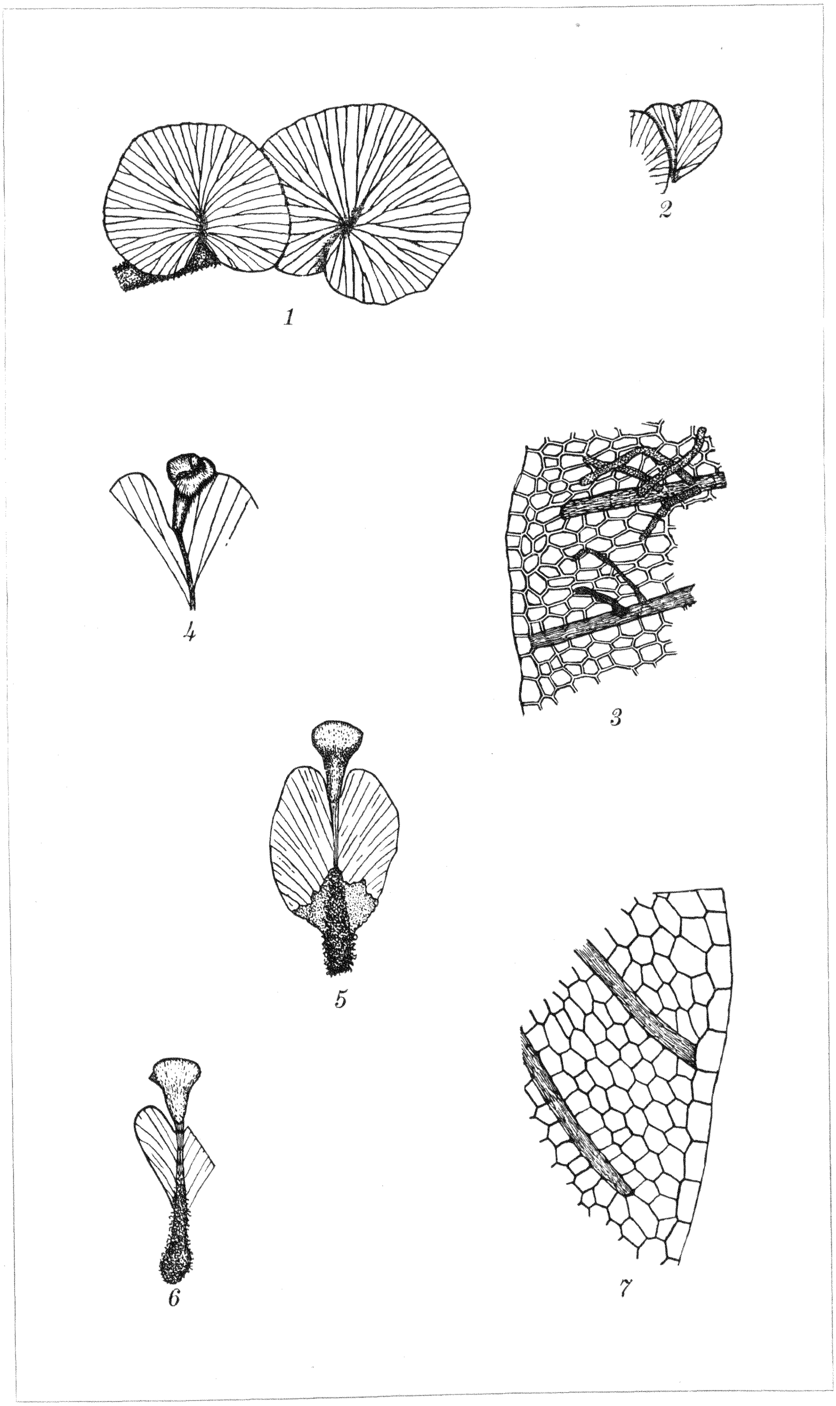

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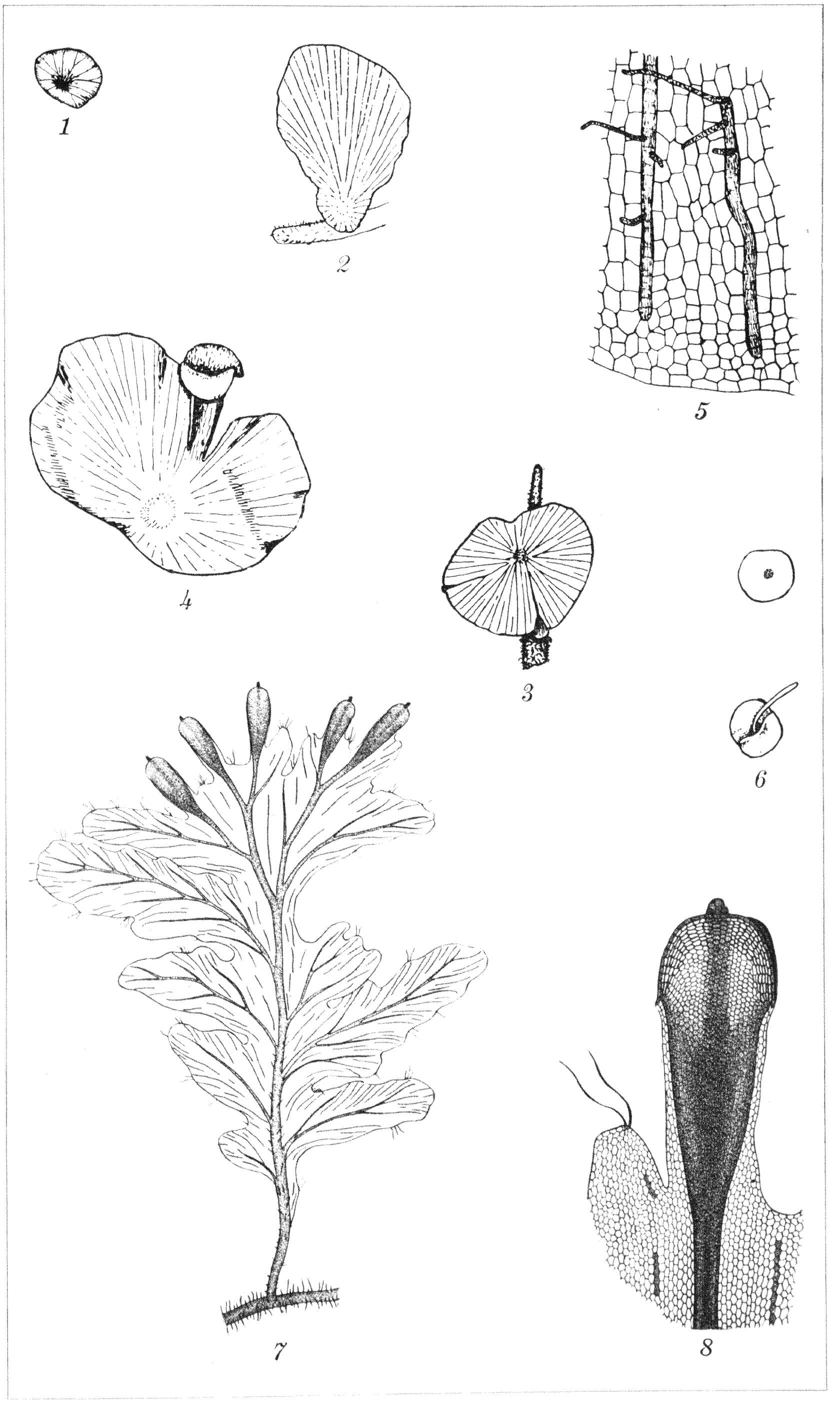

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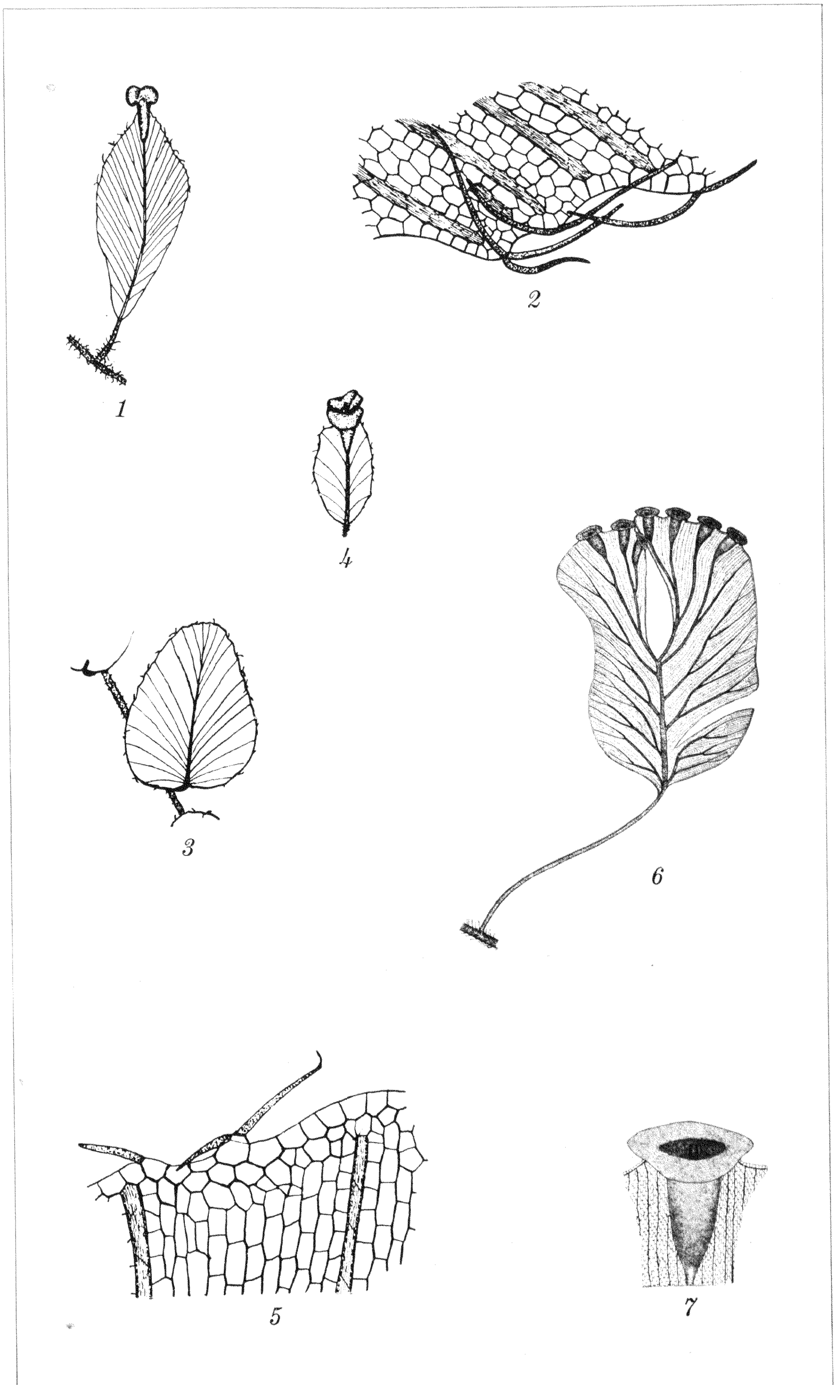
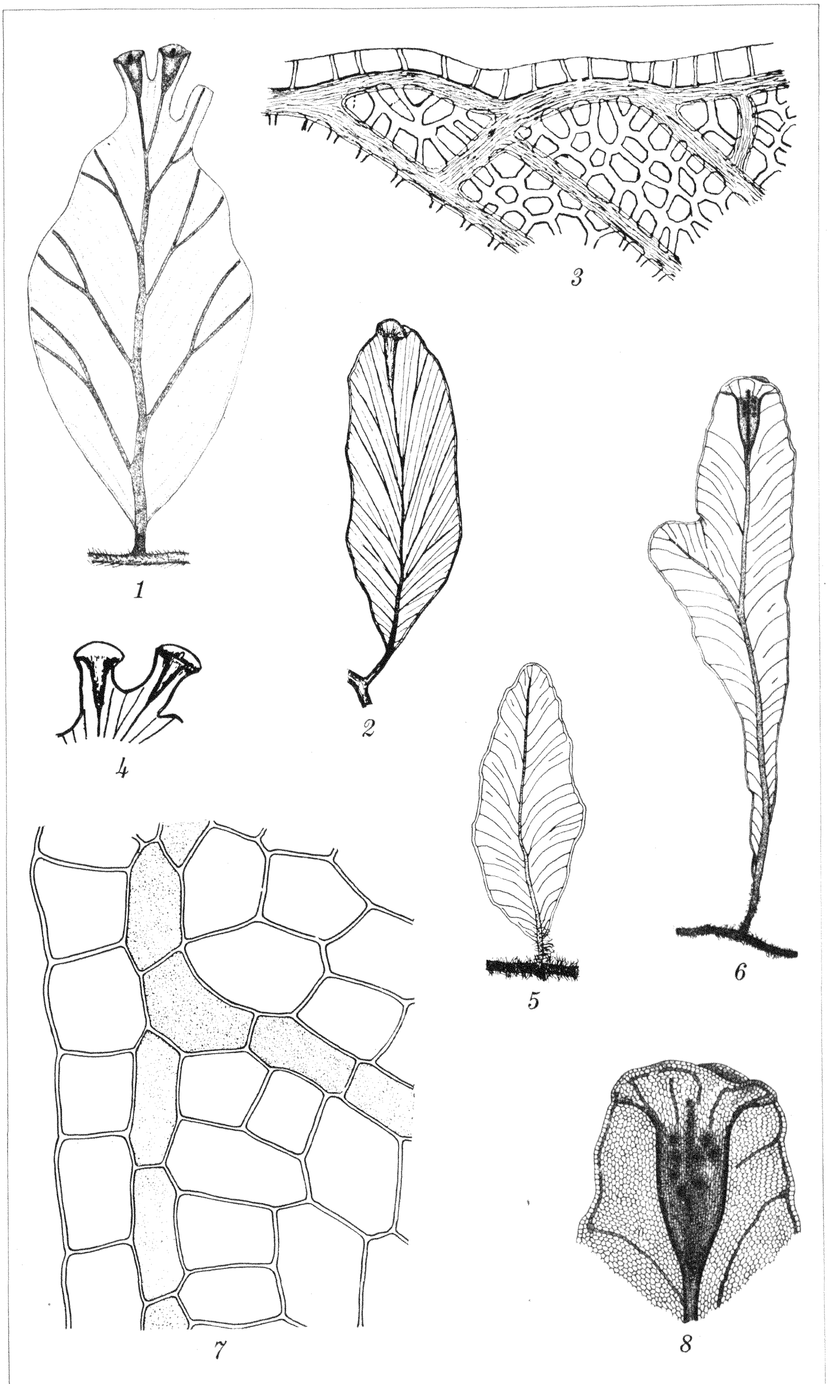


PLATE 32.



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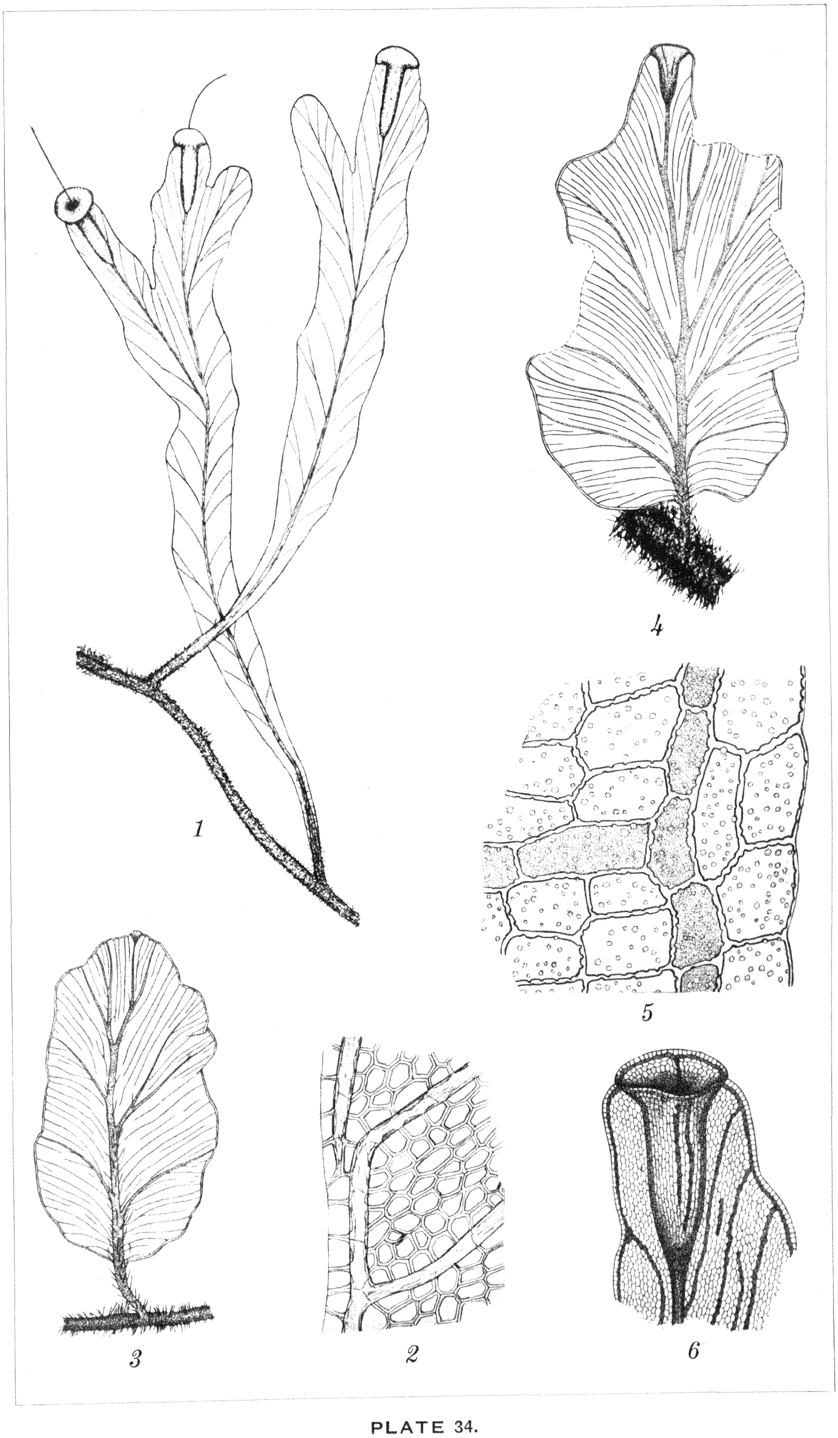

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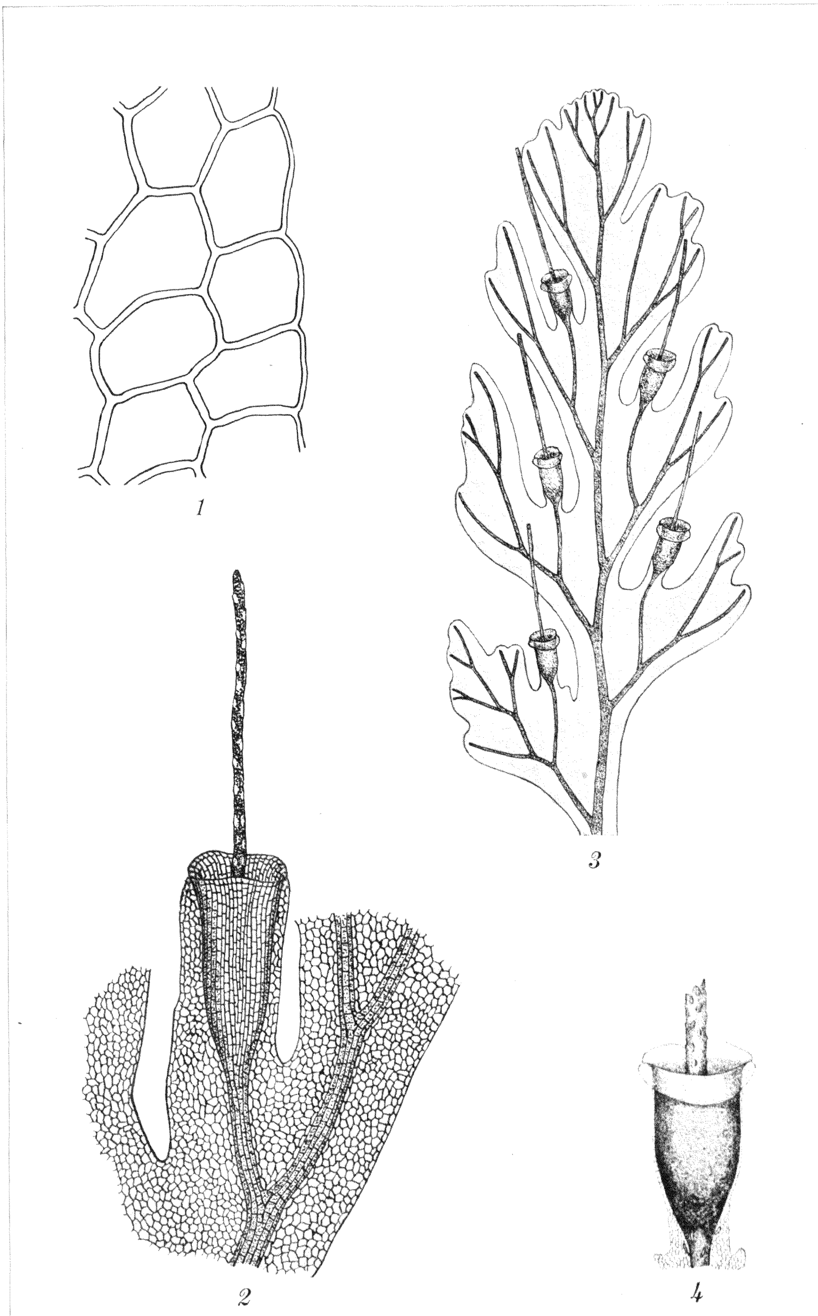

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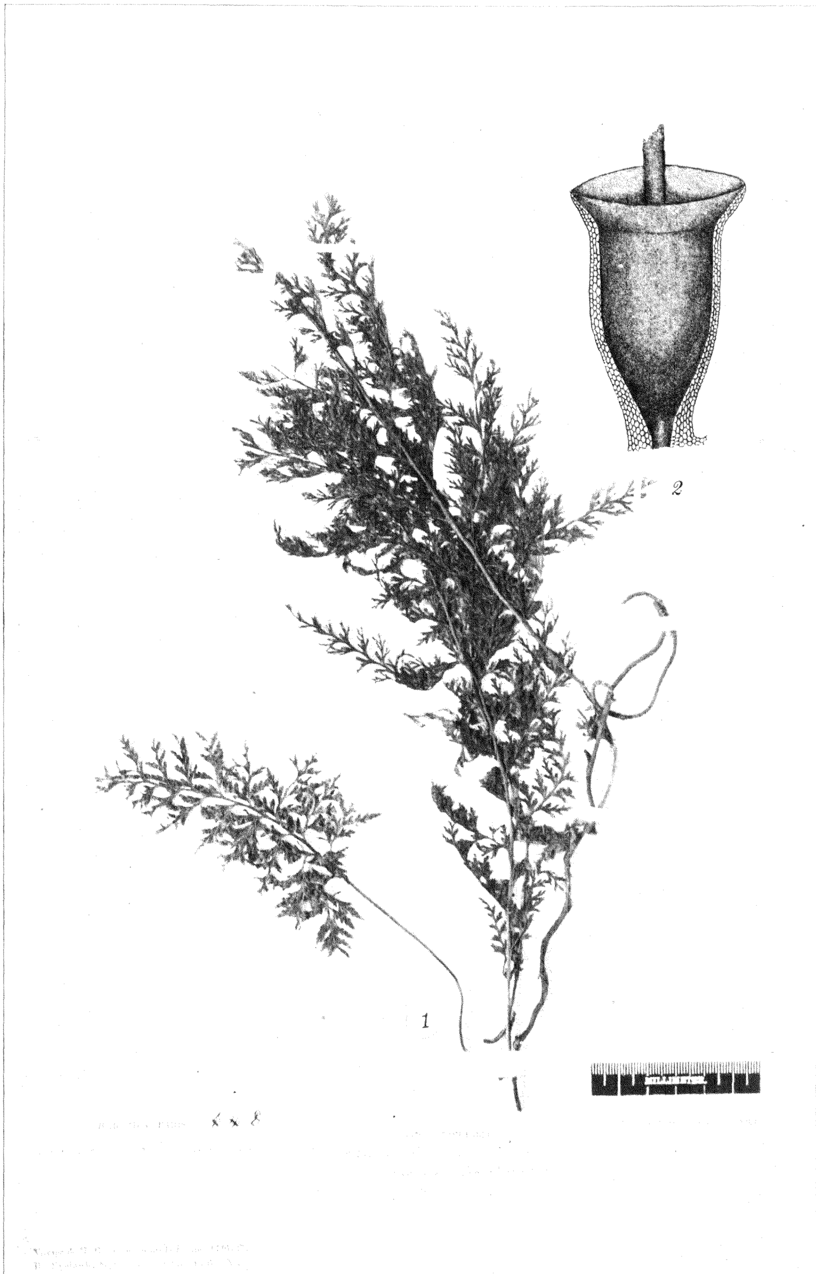

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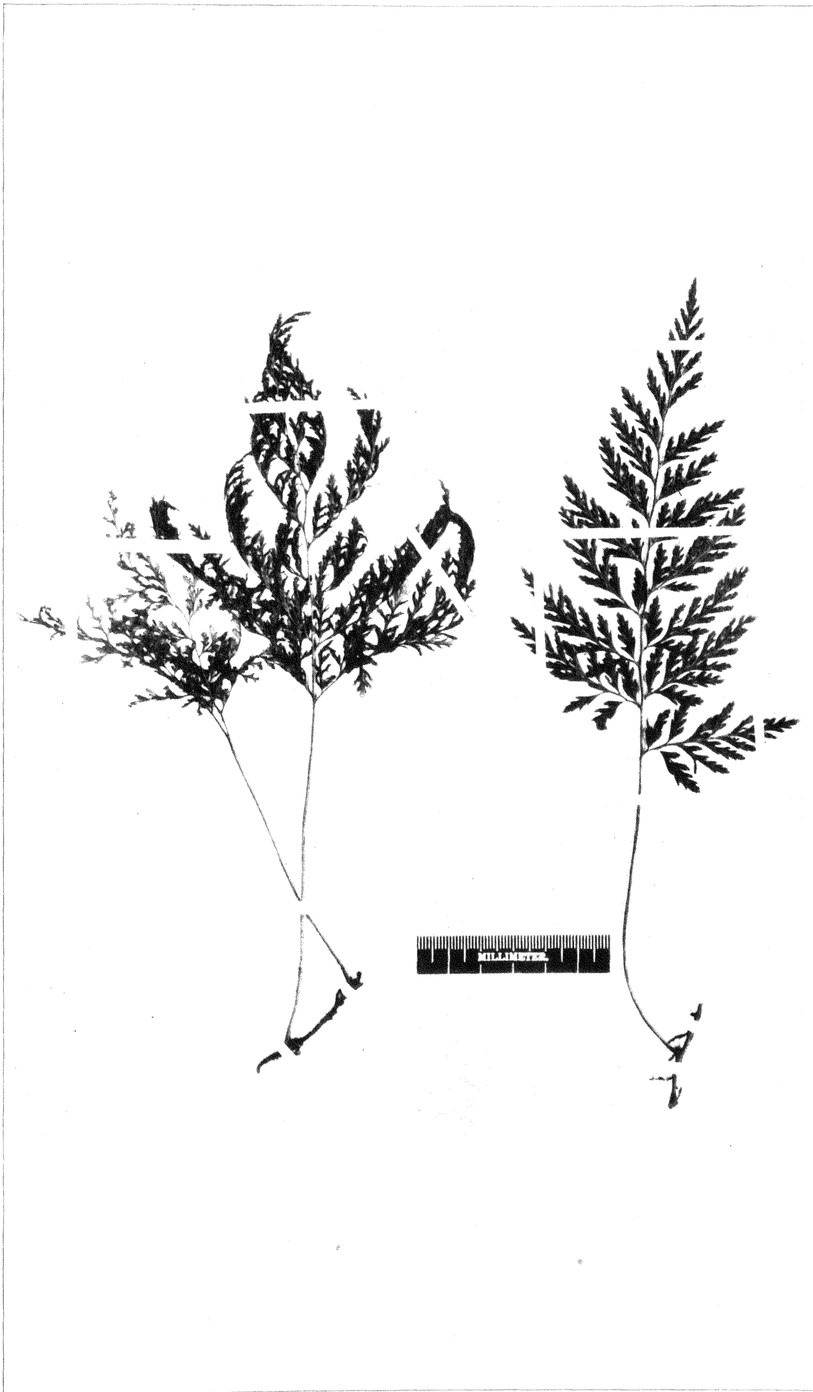

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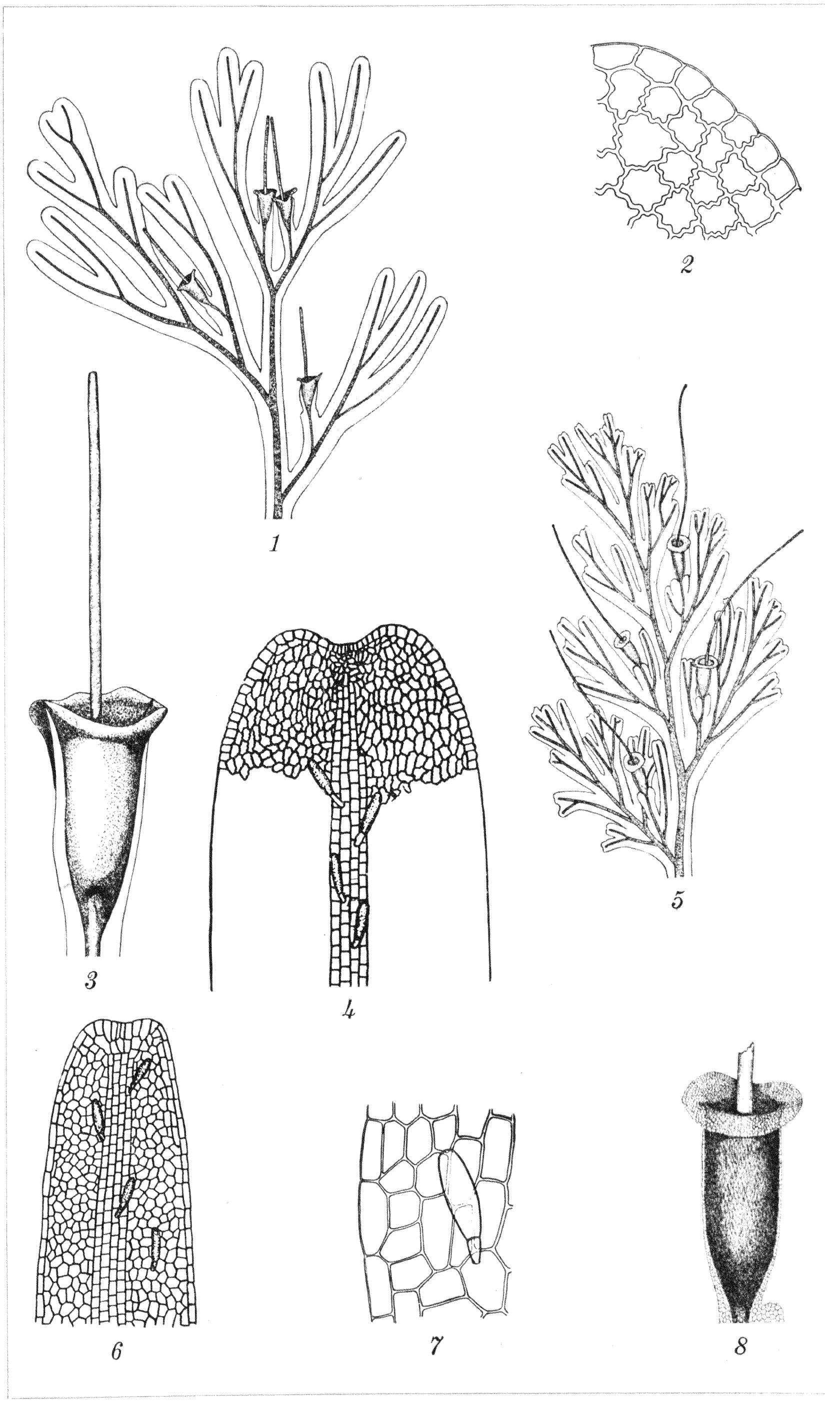

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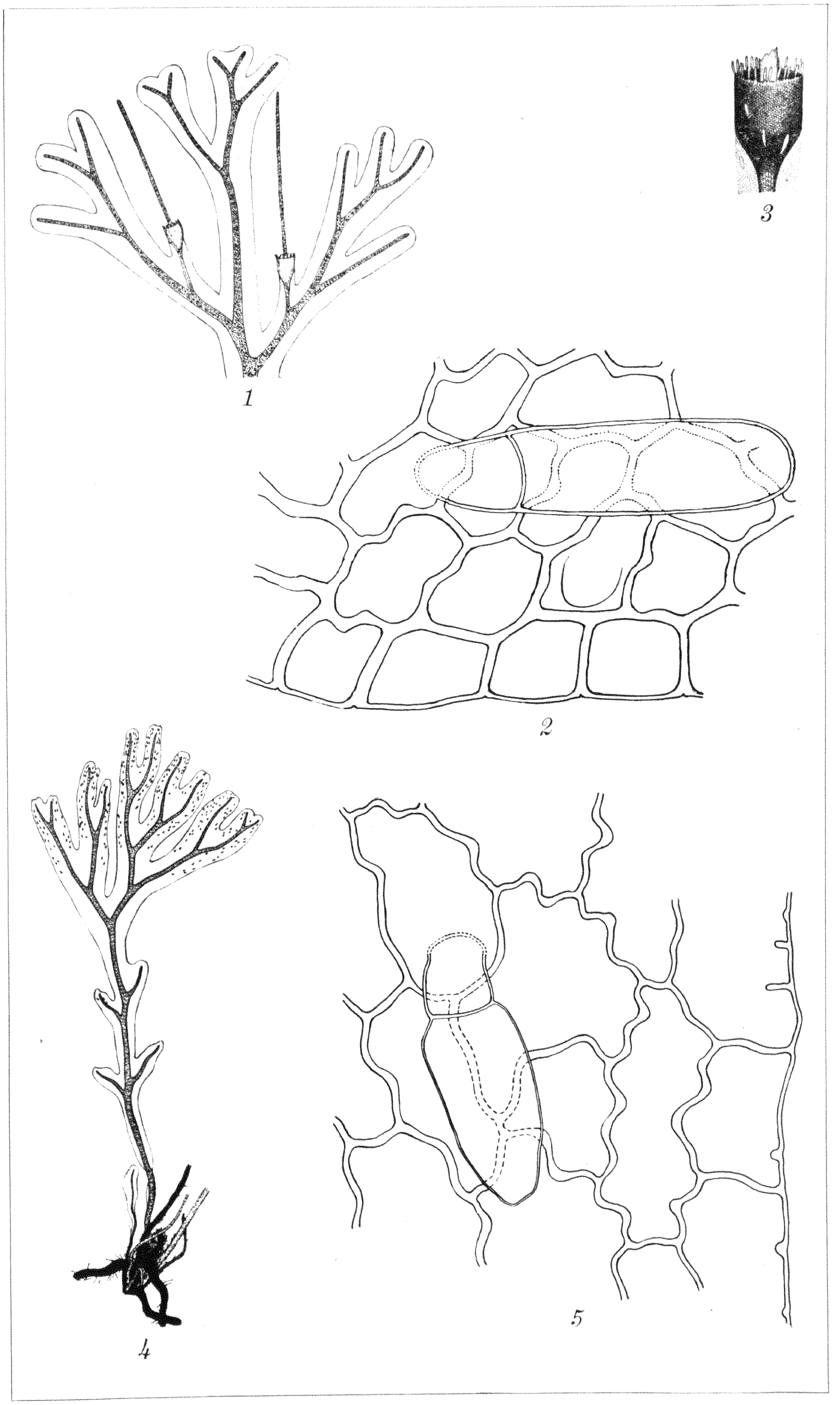

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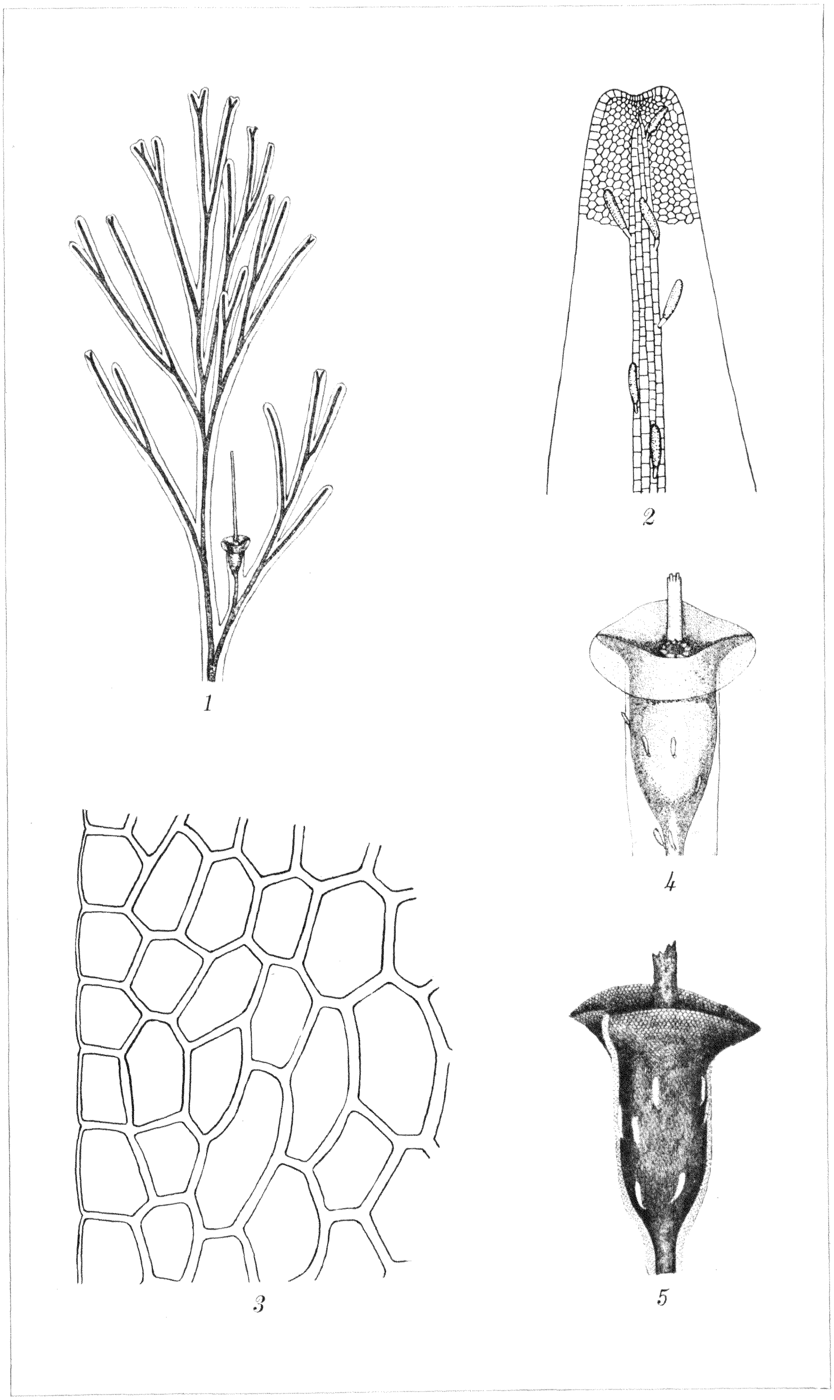

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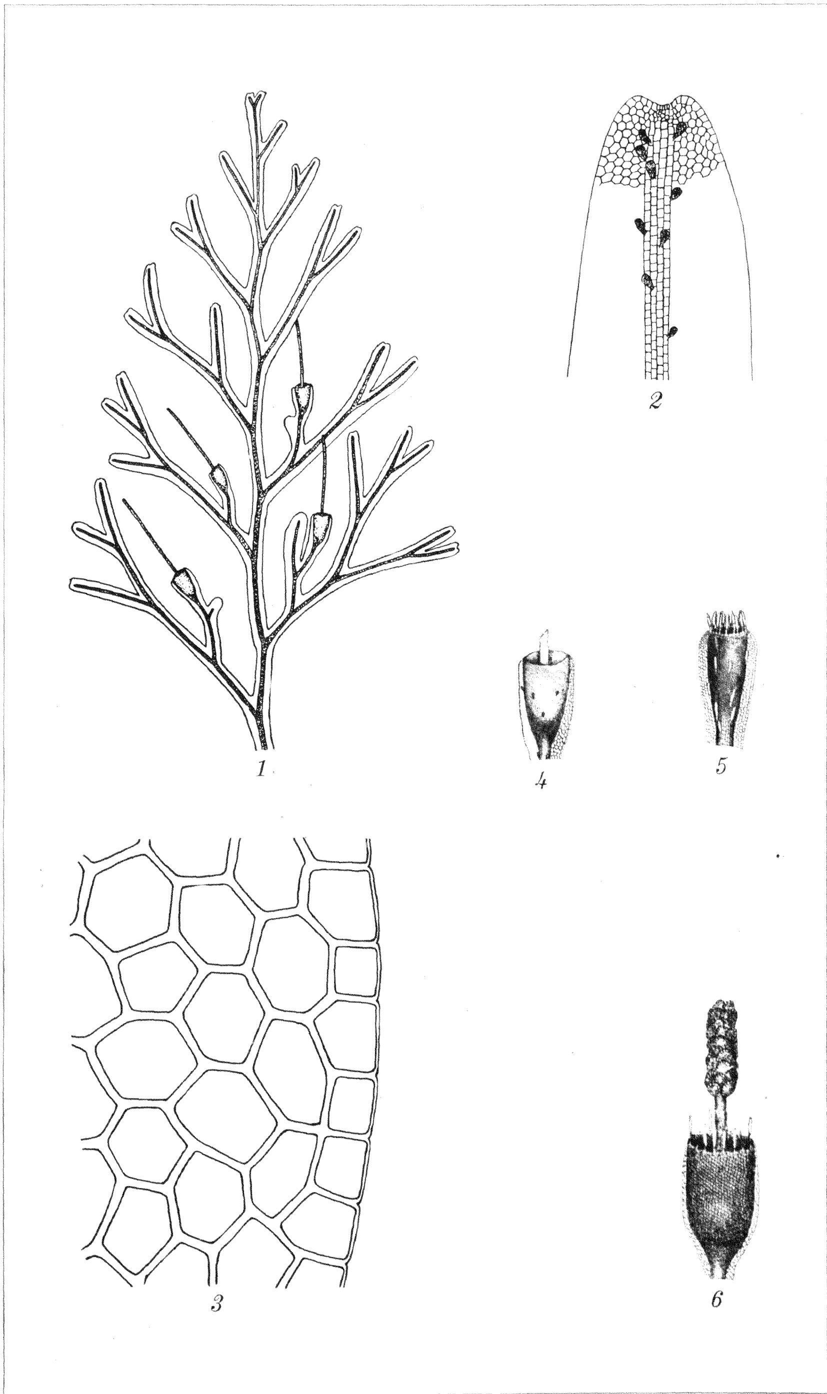

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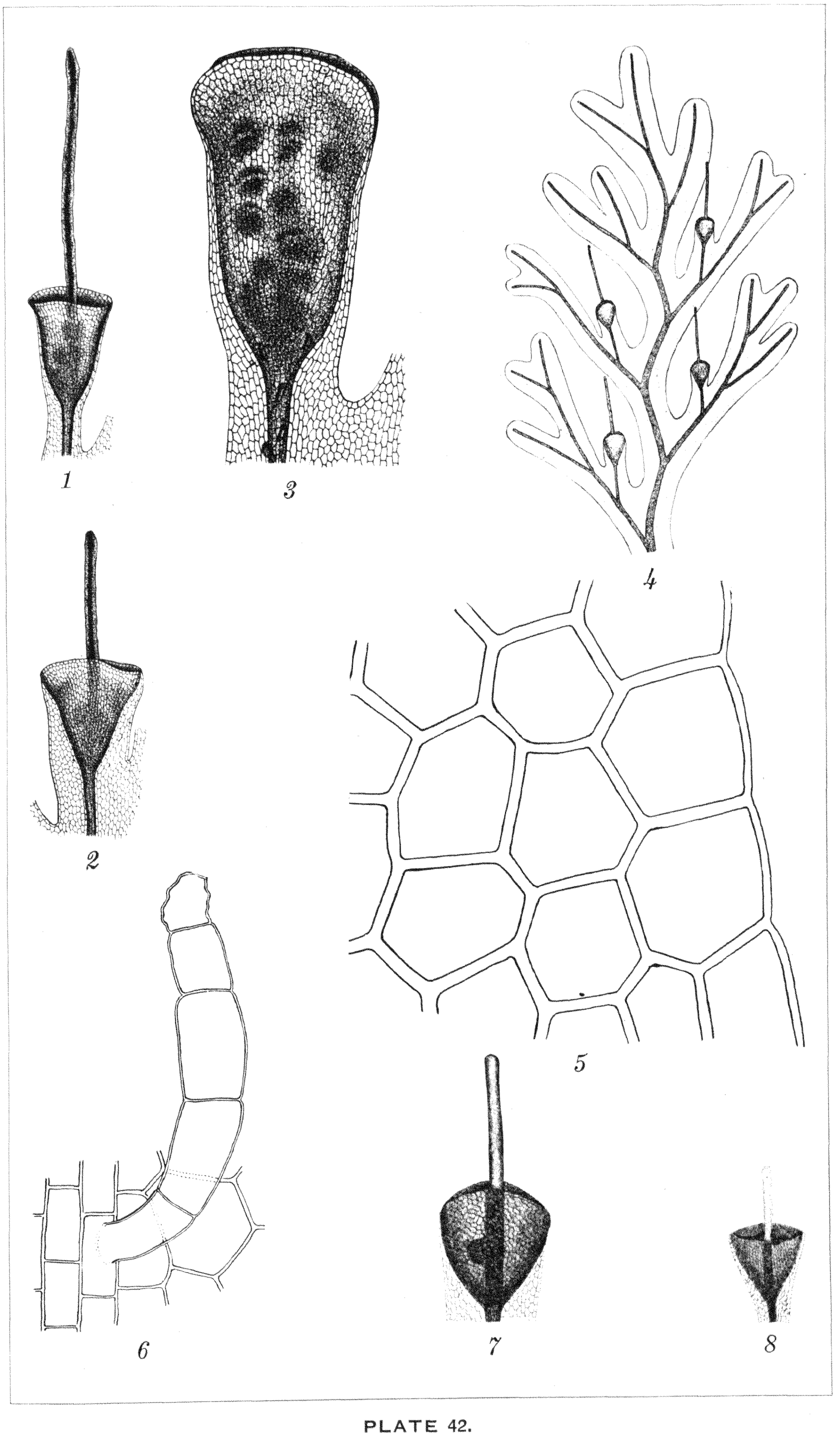

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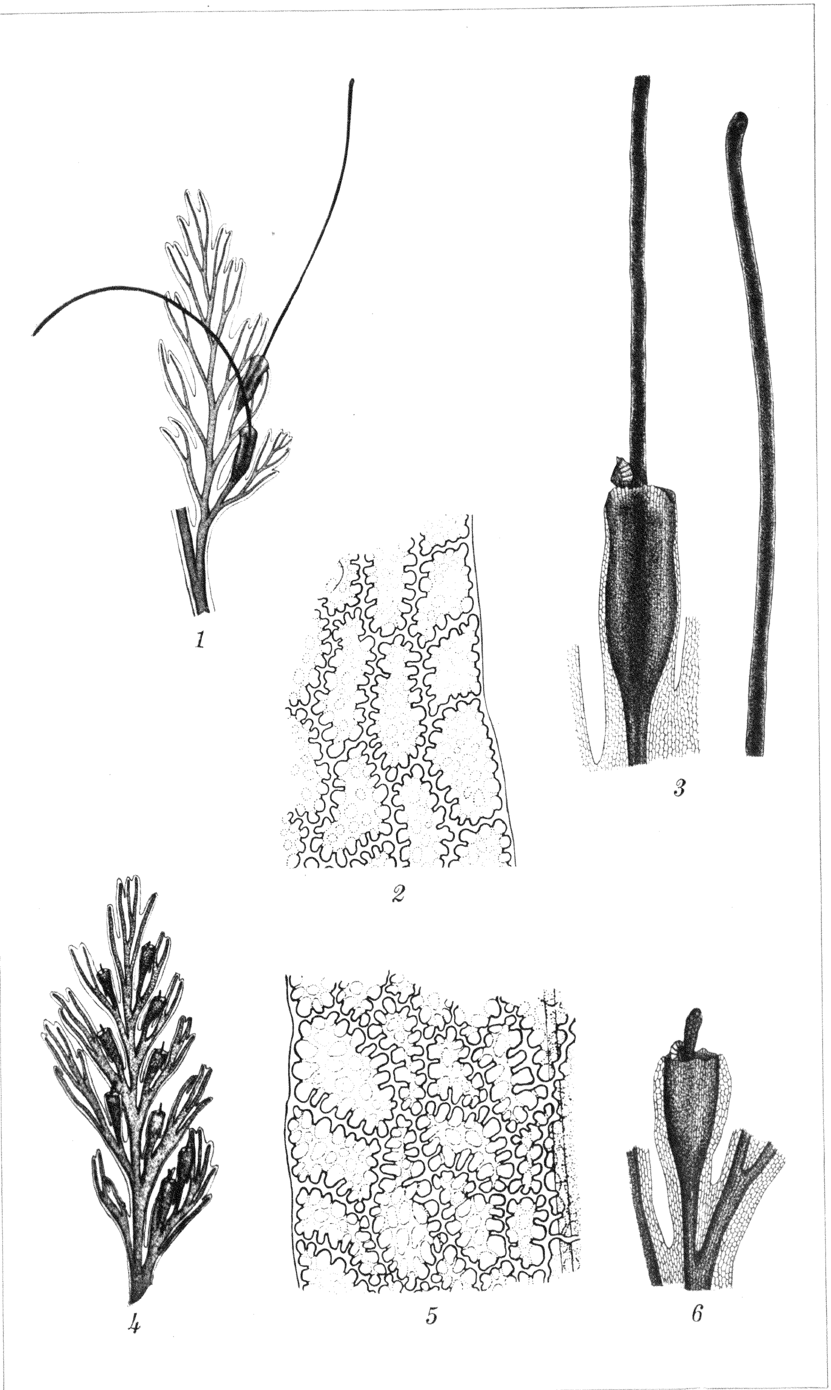
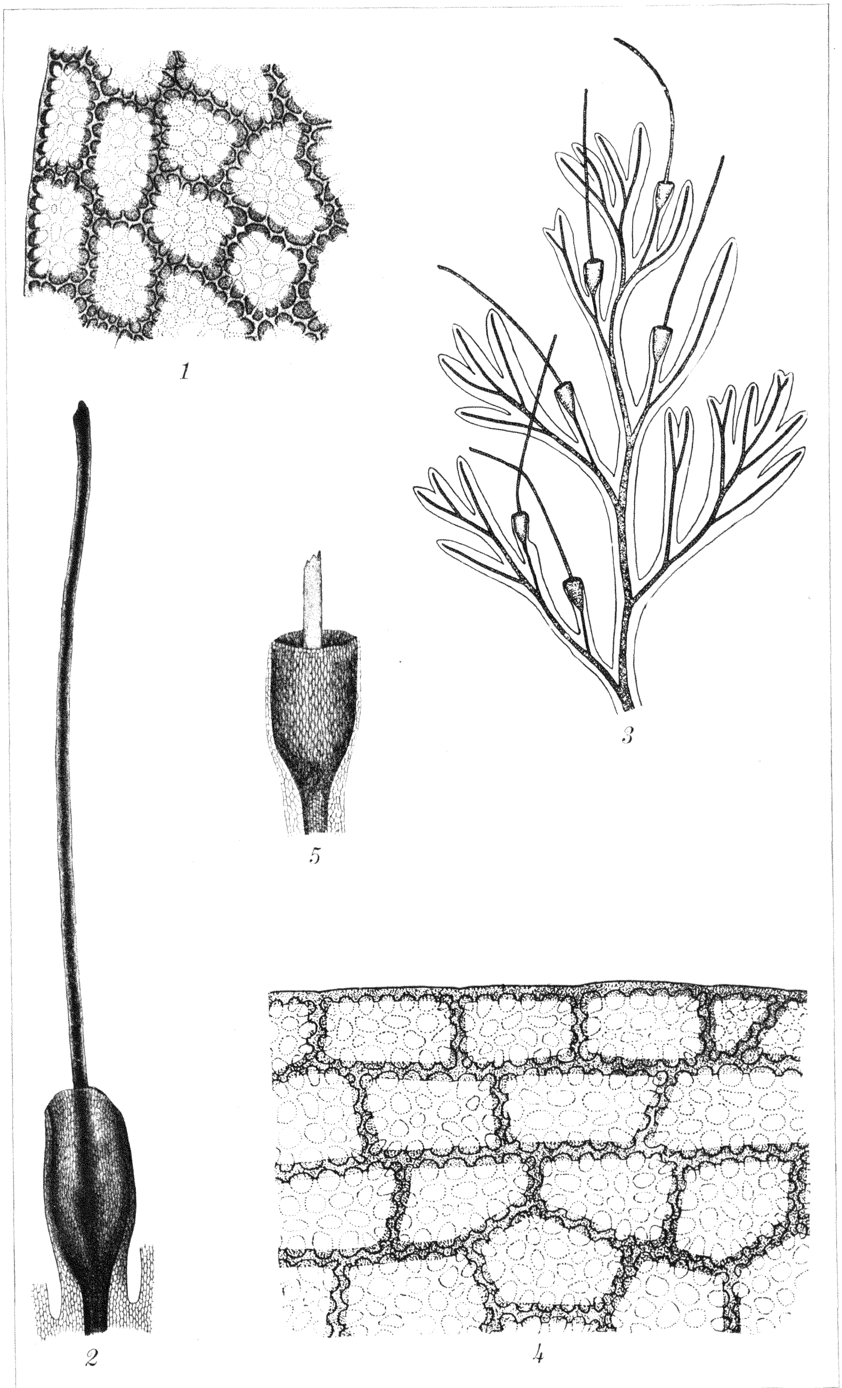


PLATE 43.



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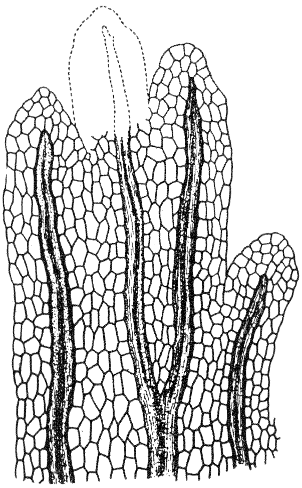

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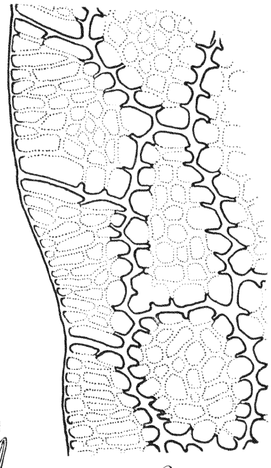

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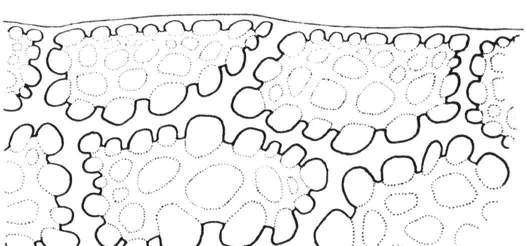

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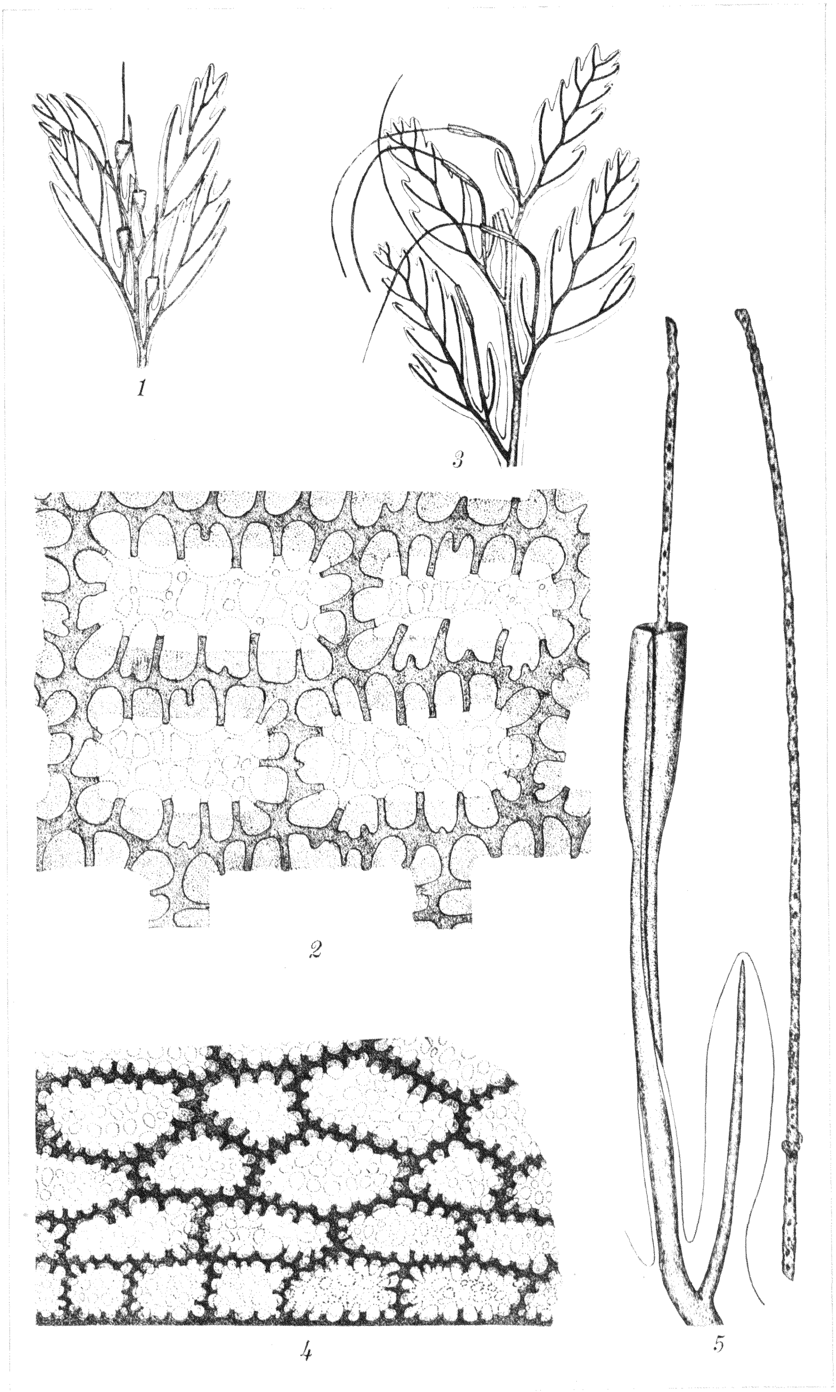

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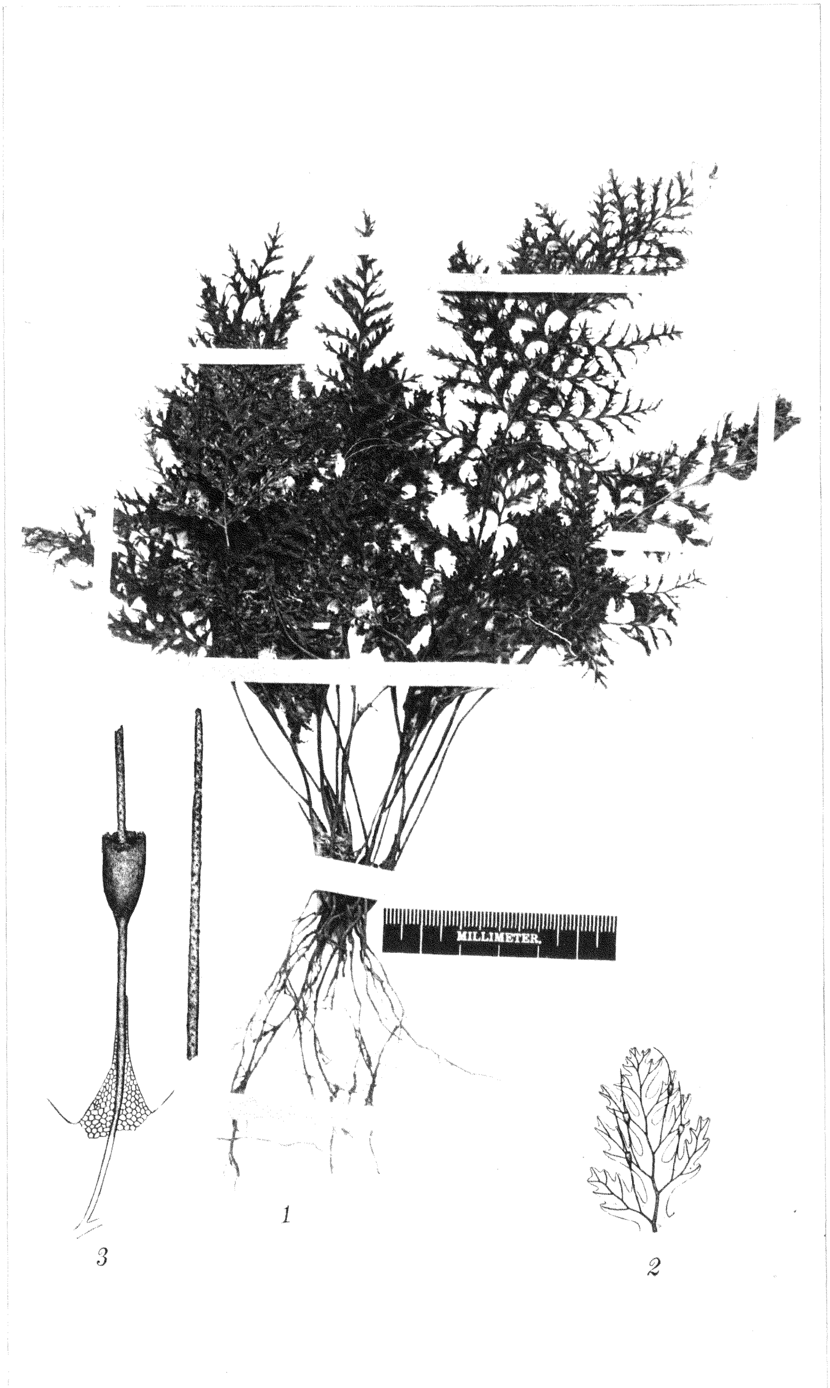

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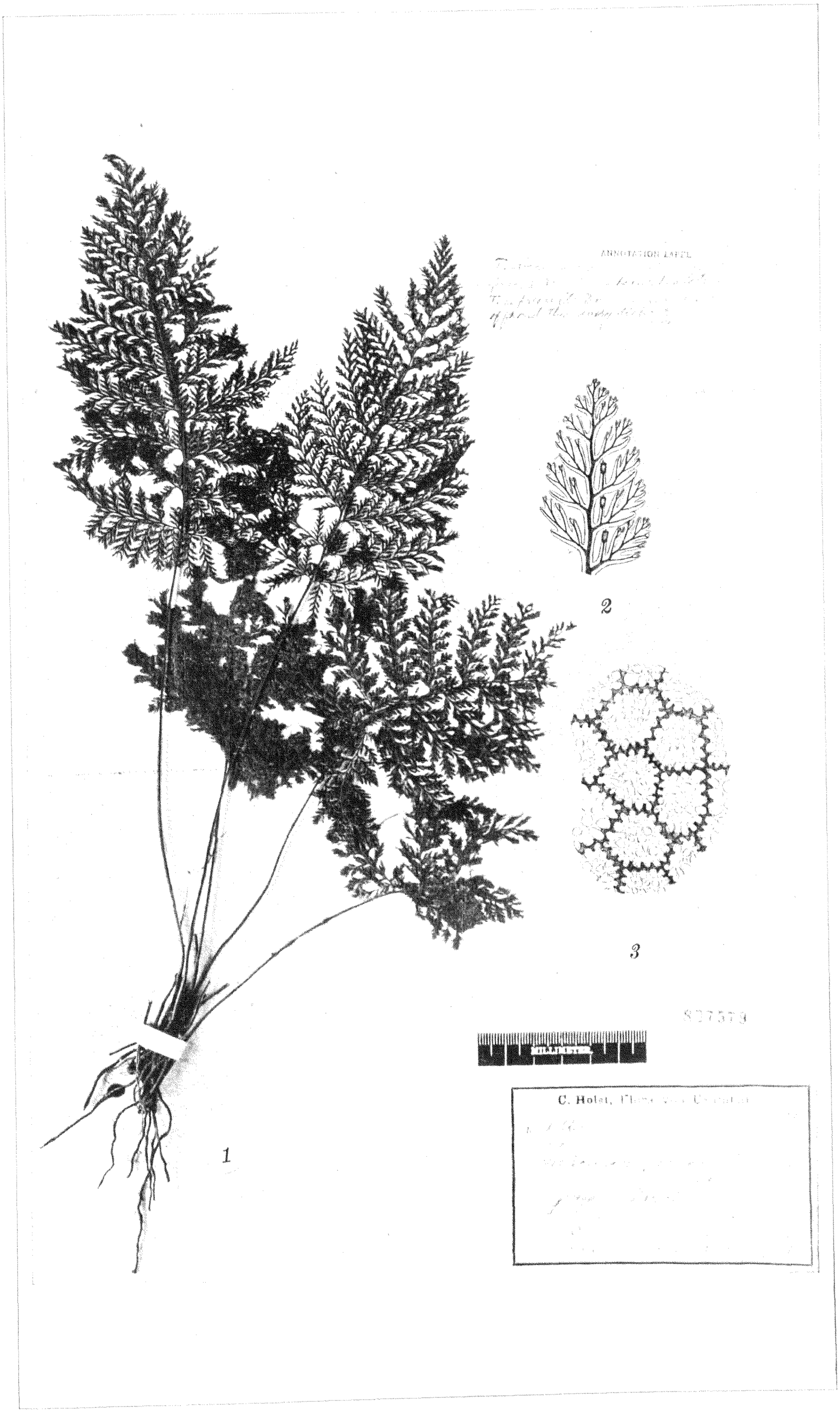

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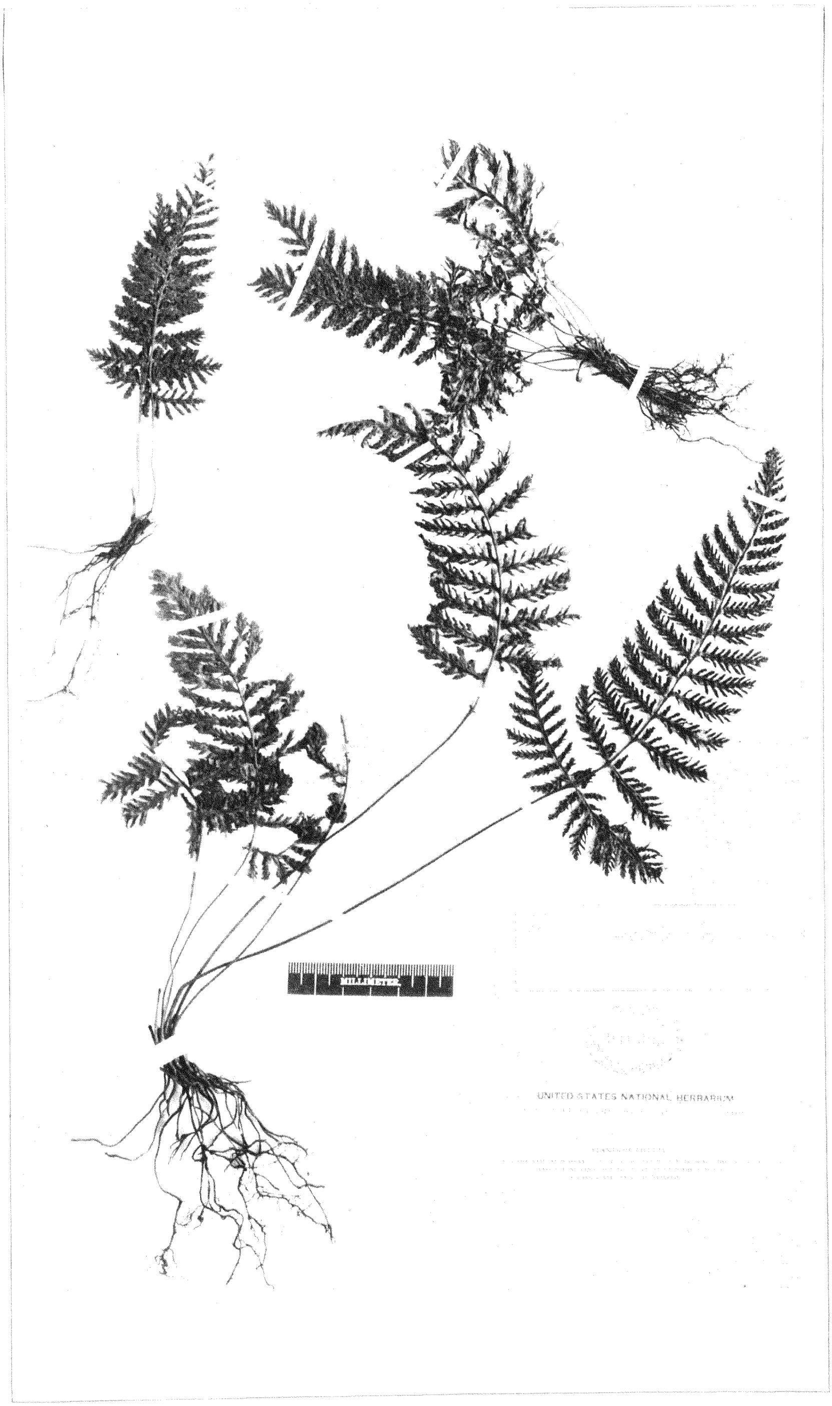

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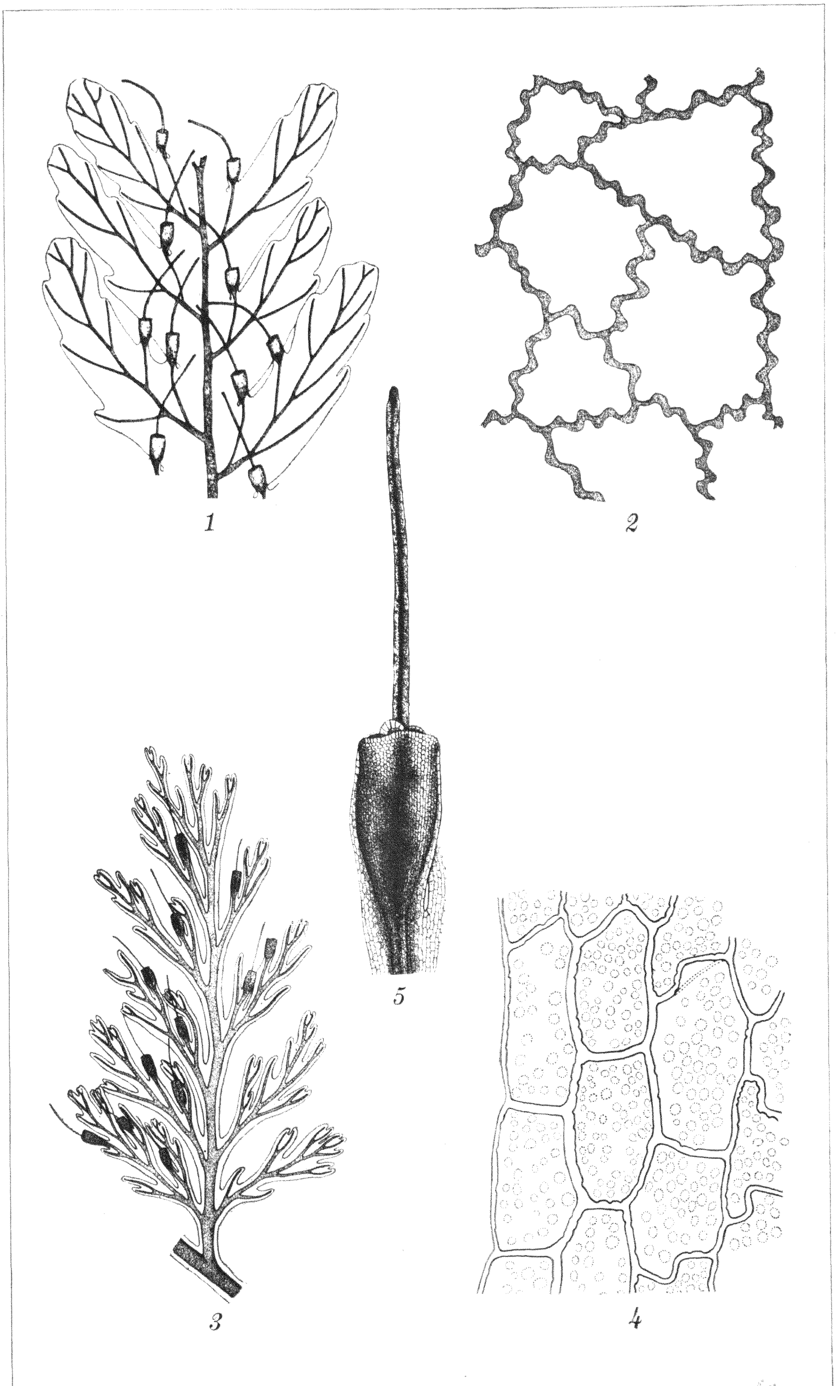

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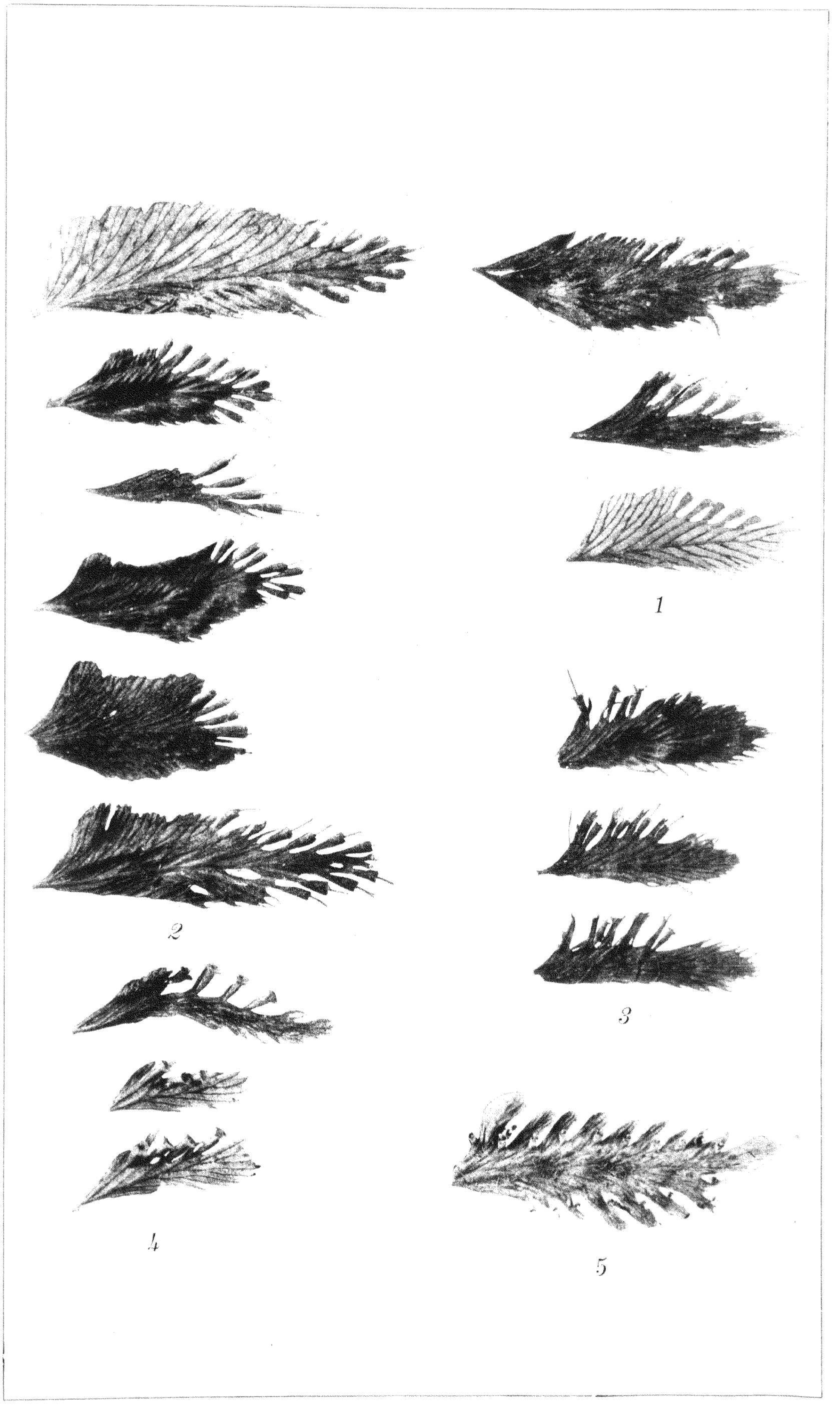

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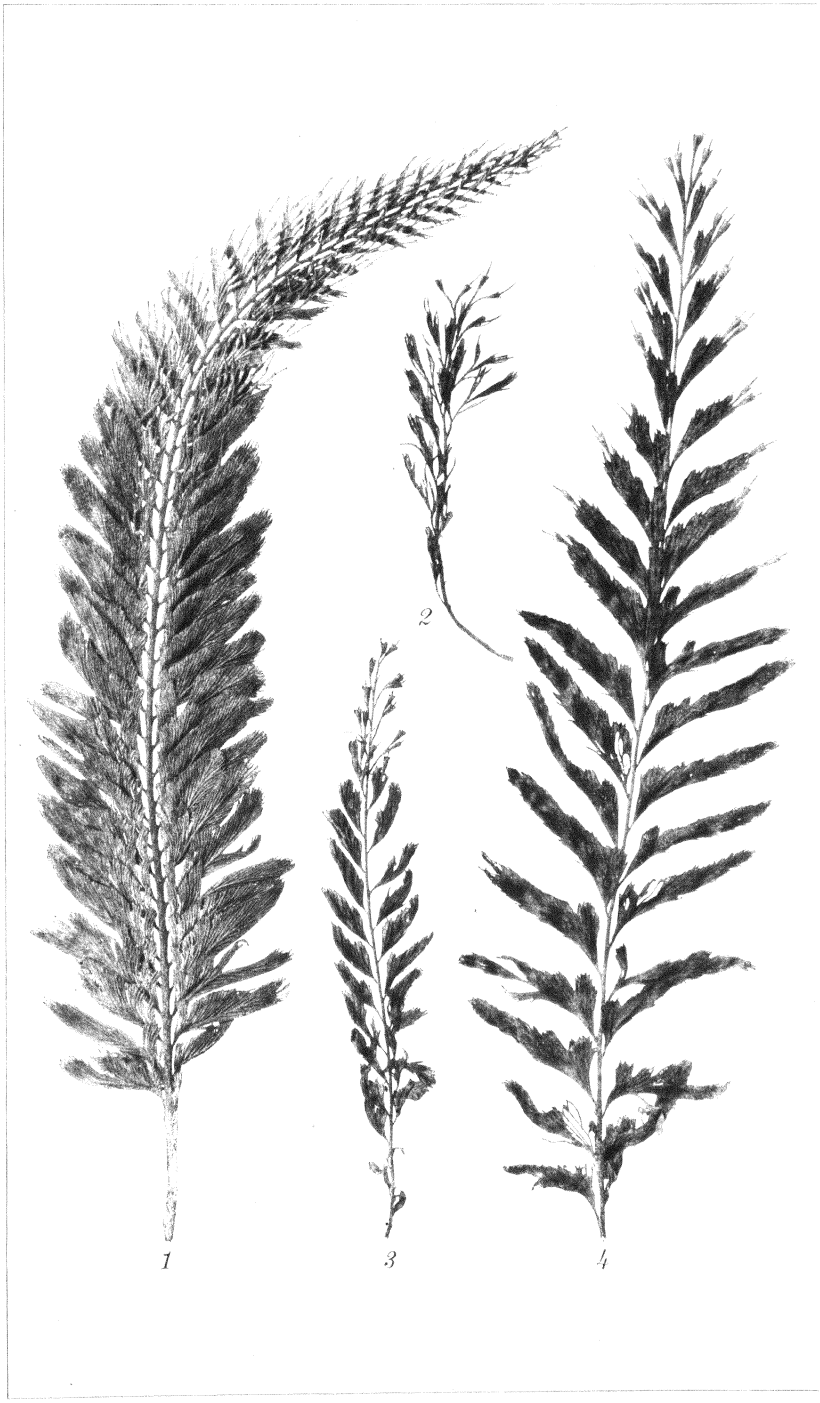

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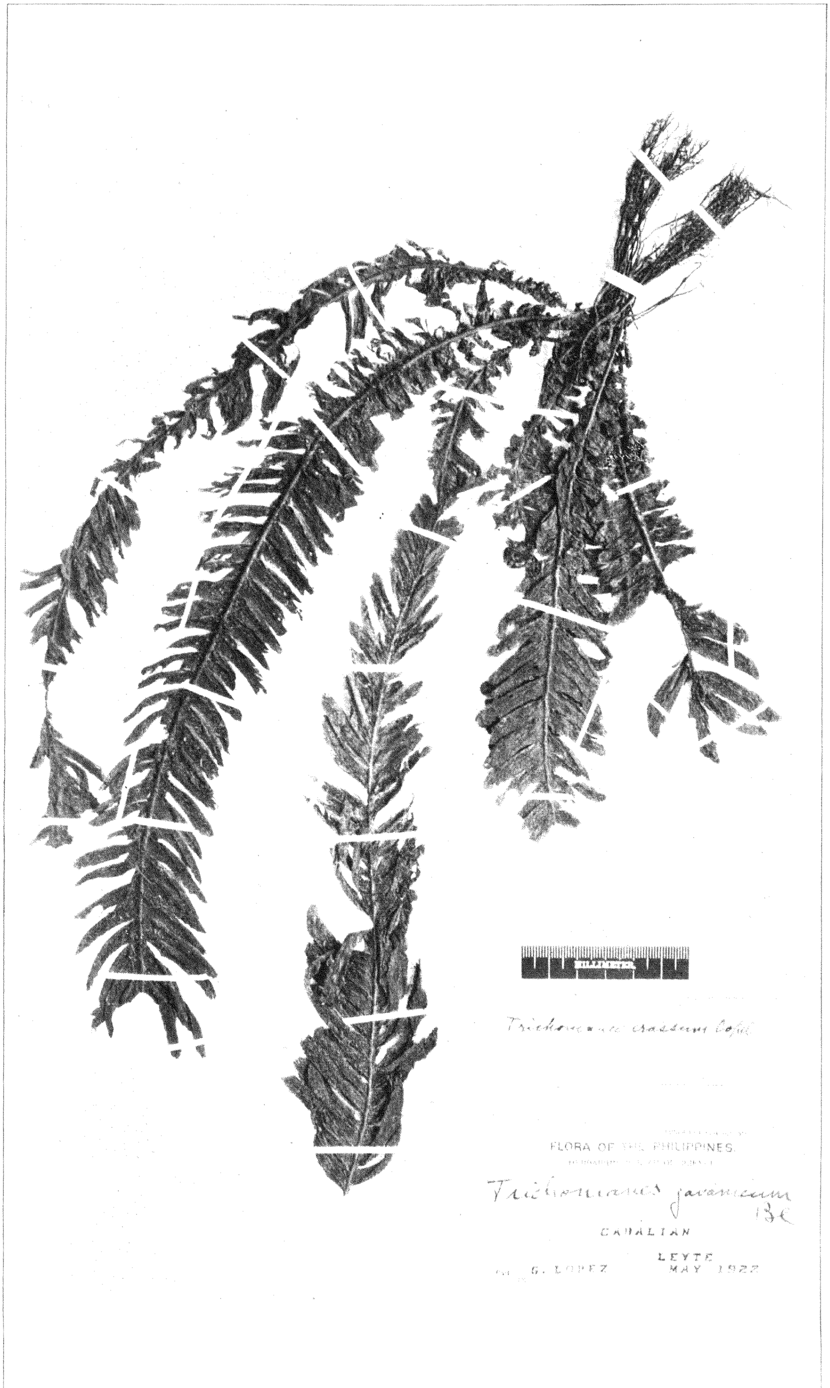
Trichomanes crassum Copel.
FLORA OF THE PHILIPPINES.
Trichomanes javanicum
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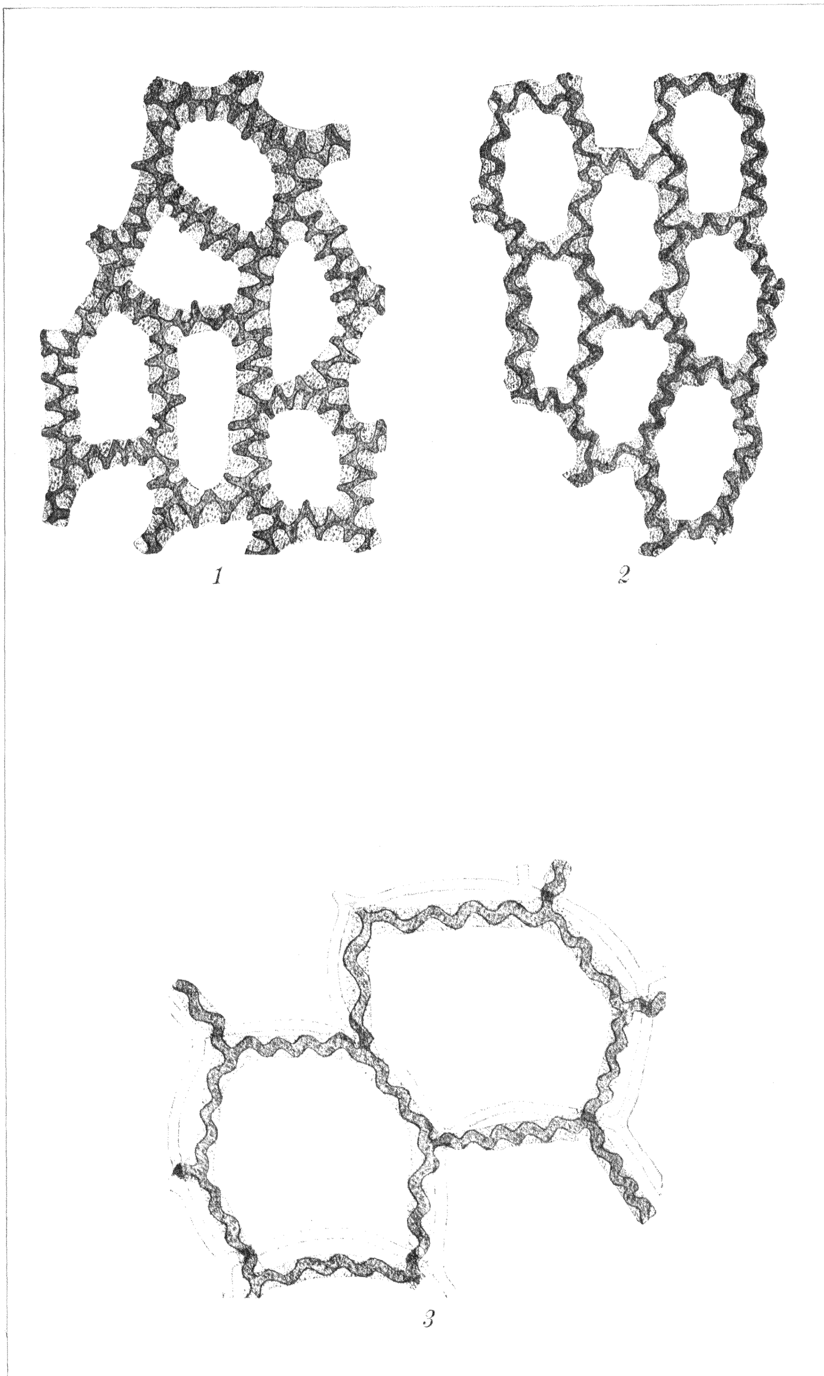
MAY 1922

PLATE 54.



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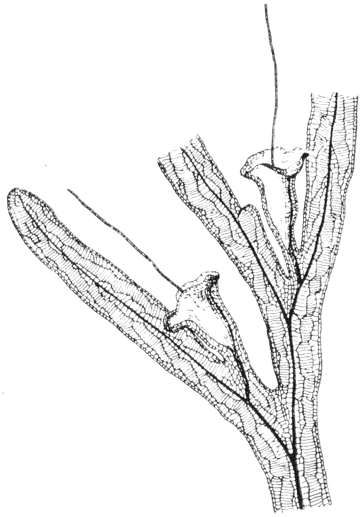

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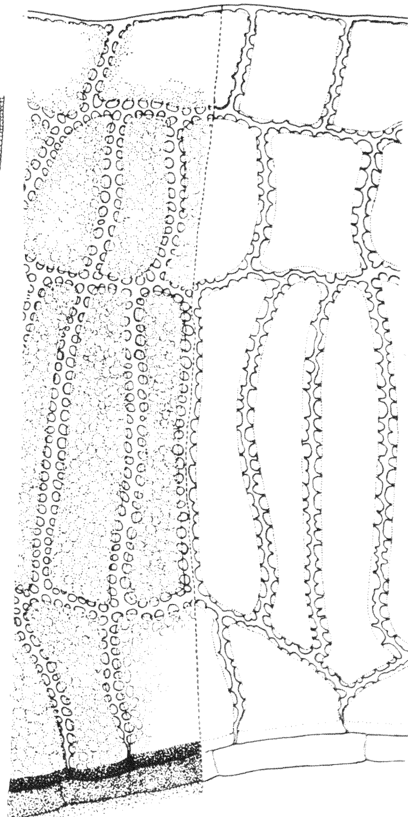

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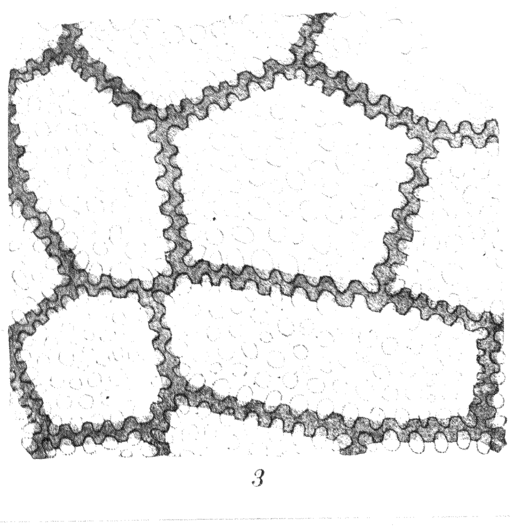

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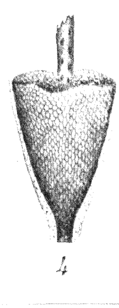

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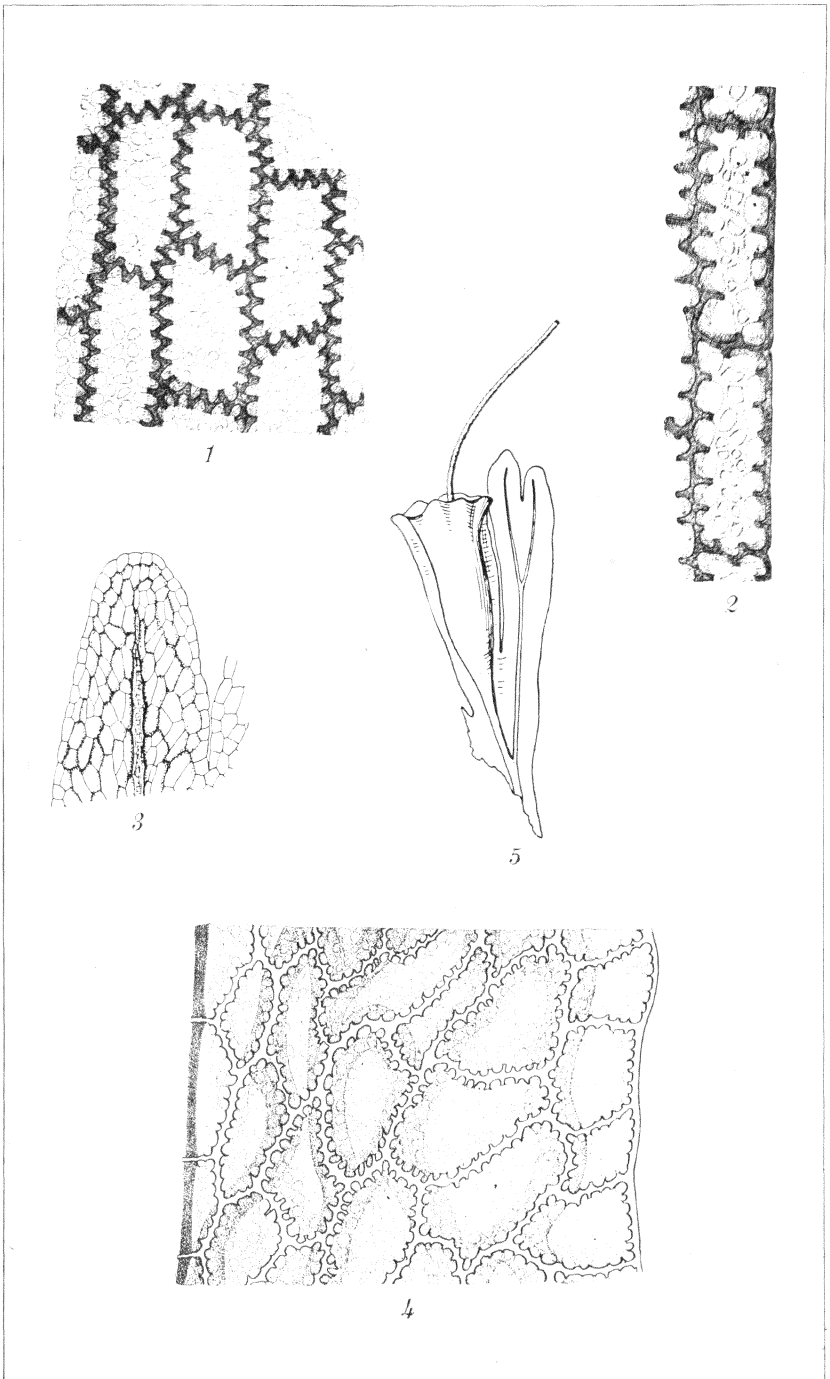

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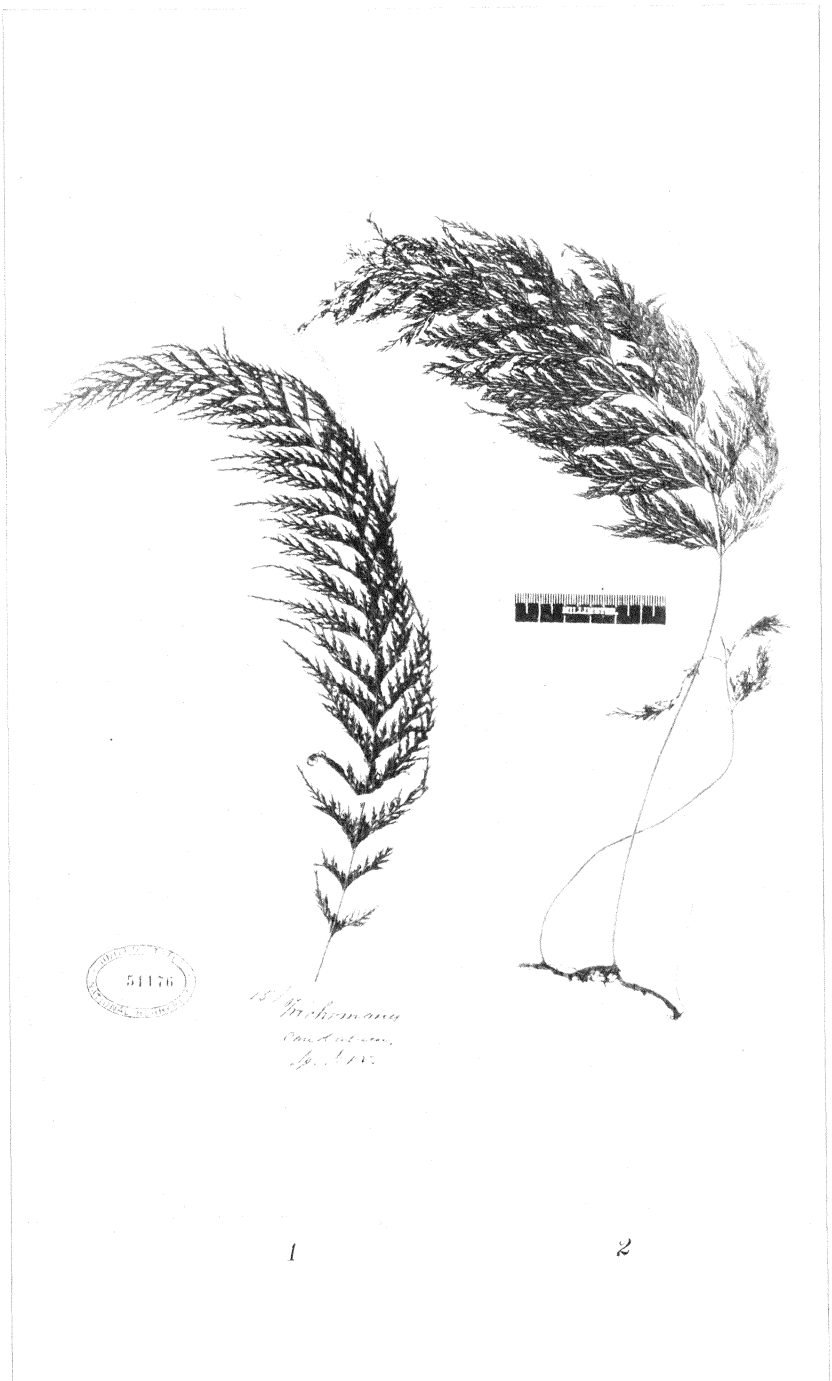

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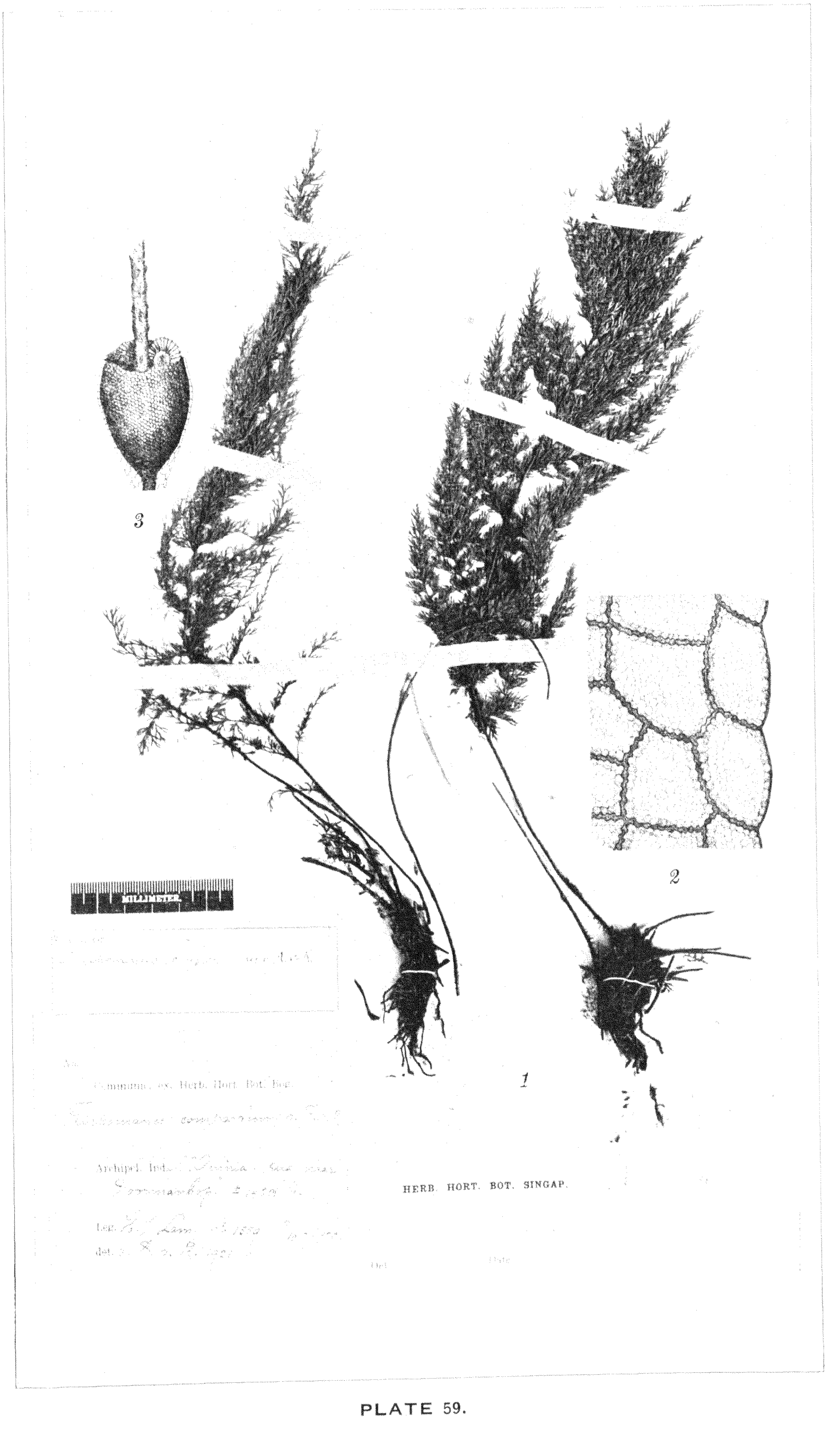


PLATE 59.

PLATE 60.

PLATE 61.

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 51 JULY, 1933 No. 3

CONTRIBUTIONS TO THE STUDY OF THE INTERNAL SECRETING GLANDS IN FILIPINOS, I

TOPOGRAPHY AND SIZE OF THE THYMUS

By JUAN C. NAÑAGAS

Of the College of Medicine, University of the Philippines, Manila

ONE PLATE AND FIVE TEXT FIGURES

INTRODUCTION

Although there is, as yet, no definite functional entity that is clearly attributed to the thymus, and no uniformity of physiological reactions or of clinical manifestation is observed under varying degrees of change in size, topography, and morphology of this organ, conditions that have caused it to be named the "enigmatic organ" of the human body; yet because of the apparent indispensability of this gland, both to lower forms and to man, and of its close physiological relationship with the many other ductless or endocrine glands and lymphoid tissues of the body, and because of the significant influence that these have upon the form, type, and extent of physical growth of the body systems, in different families and races of people, it becomes of importance and of interest to know the actual degree of development and the true anatomical state in which this gland is found in Filipinos.

Racial differentiation, anthropologically and morphologically, is known to be brought about in some way by the varying influence of the secretory activity and alteration in the harmonic balance of the internal secreting glands of the body. From analogy, from observations on certain diseases affecting some of these glands, it has been claimed that variations or changes in

their secretions tend to produce certain distinct anthropologic types, with the predominance of such characteristic anatomical features as those found in the mongoloid, acromegalic and cretins, and infantile forms of development. Although many other factors undoubtedly help in the formation of the very numerous shades of forms and appearances of the external features in the developmental processes of man, from one extreme to another, yet the part played by the endocrine organs is believed to be as fundamental and as inherent as the influence of heredity. These two factors, aided by the nutritional and environmental secondary influences, are the preëminent and dominant controls now known to influence such body processes. Study of the internal secreting glands in Filipinos will help disclose some of the distinct morphologic and developmental standards characteristic of the Filipinos as they should be studied in anatomy, and as bases for the collateral studies in physiology, pathology, biochemistry, and other medical sciences that directly concern the race. Their study, particularly those of the thymus and thyroid, will probably offer likewise some clue to the time-extent of the various phases of growth and development as met with in the intrauterine, childhood, adolescent, and senile periods of life in Filipinos.

Nothing definite is known about the normal or common condition of development of the thymus in Filipinos, and collaterally practically nothing is known either of its peculiarities or of its abnormalities and pathology as they occur in the Tropics and in the race. It is, of course, essential that we primarily and fundamentally know what is the normal or ordinary state of this organ in the body to enable us to distinguish what is unusual or abnormal. It is thus the purpose of this paper to present primarily, in a preliminary way, the findings obtained from our study of the position, topographic relations, size, weight, and dimensions of the organ as actually found in Filipinos.

CONSTITUENT ELEMENTS AND EMBRYOLOGY OF THE THYMUS

All the anatomical features and experimental facts so far found about the thymus tend to show that this organ, like some of the other structures of the body known as internal secreting glands, really possesses more than one function and that such functions are in direct and in collateral relation with the two fundamentally different and morphologically distinct structures of the thymus; namely, the medulla, with its concentric corpuscles of Hassal, of strictly epithelial origin, and the cortex, with

its characteristic lymphoid tissue contents, which are of mesenchymal source. These two structurally distinct parts are now recognized as of fundamental significance in the rôle they play in the proper growth of the various body structures and systems, and in the right maintenance of the normally balanced functions between the different internal secreting organs of man.

The two structures, the epithelial and the lymphoid portions, taken together, constitute the main bulk of this gland. This organ is known to appear in the embryonic stage as an involution of the pharyngeal entoderm from each side of the future pharynx. It soon separates from this origin and becomes an independent structure, which then takes its place in the lower cervical and upper thoracic regions in man. The entodermal anlage of this organ becomes the concentric corpuscles of Hassal, and it is the specific and fixed element of the thymus. The lymphoid tissue contents of the cortex are of mesodermal or mesenchymal derivation, and they are at present regarded as an immigrant or accretion element of the thymus. It has been stated, and to a certain extent accepted, that the thymus continues to enlarge in size and in volume to the second year of life. From this stage to the period of puberty it remains stationary. Upon reaching the age of adolescence it begins to diminish in size at a slightly varying rate, although it is found that it does not completely disappear. A certain portion of it usually persists, which is believed to continue to exercise some functions during the entire life-time of the individual. In fact, it is now presumed that the diminution in size of the organ is due only to an emigration of the lymphoid tissue element, and that the epithelial part is not much affected and persists for a longer period.

As to how the evolutionary changes enumerated actually occur in the different stages of life in Filipinos, and at what rate and to what limit this organ continues to grow in the race; and once its maximum size and usefulness are reached, what relative extent of regressive changes is undergone by this organ, are questions and problems of intriguing interest and importance, especially in connection with the study of those problems directly related to the physical and constitutional make-up of the race. Such problems are closely allied to the various processes of body growth and development and are intimately related to the different alergic conditions inherently connected with the resistance of the body systems to various diseases that are commonly observed in Filipinos. To help solve the aforesaid

problems on the growth condition of the thymus in Filipinos, there are, of course, required many painstaking observations on actual human material that should be comprehensive enough to cover the entire span of life. It is obvious that the study on the topography, dimensions, and ponderal condition of the organ calls for the first attention; and, therefore, it is the first inquiry and study that is followed and here presented. We hope that other problems, of a more-advanced nature, on the study of the thymus can be attended to later.

MATERIALS AND METHODS

For this study of the thymus there were dissected, examined, and measured 338 bodies, both fresh and embalmed, that ranged in age from birth to 15 years. There were 202 males and 136 females. These cases were divided into three series for age-grouping and for other technical reasons. The first series includes those full-term stillborns or newborns who died during or soon after delivery. In these cases all the important body dimensions were taken, and the thymus was carefully dissected out, measured, traced, and its topography carefully studied. This group numbered 29 cases, of which 17 were males and 12 were females. The members of the second series were newborns 24 hours to 2 days of age, in which the body dimensions were also taken and the dimensions and weight of the gland were also carefully recorded though its topography was not traced. There were in this group 164 cases, of which 100 were males and 64 were females. The third series comprised those cases that had lived from 2 days to 15 years. In this group the thymus was carefully measured in autopsy, although no tracing of its topography could be made. This series numbered 145 cases, of which 85 were males and 60 were females.

It is to be mentioned, in this connection, that many of the cases belonging to the first series were fairly well-developed and well-nourished fœtuses, as shown by their appearance and weight. Many of them, as reported in their obstetrical record and as found in autopsy, died during their prolonged or difficult delivery, either through traumatic injury or through asphyxia suffered during parturition, as frequently happens in fœtuses that are fairly large. The cases belonging to the second series were of various degrees of body nourishment; some were fairly well developed while others were quite emaciated. In both of these two newborn series no material was included showing any gross pathological condition or abnormal development of the body.

The third series consisted to a great extent of poorly nourished, underweight children. The older ones, particularly had suffered from one form or other of gastrointestinal troubles from which many of them had died an early death.

The newborn fœtuses of the first and second series belong to the collections of embryos, fœtuses, and newborns of the Department of Anatomy of the College of Medicine, University of the Philippines. These were gathered from various sources—mainly, hospitals and charity institutions in Manila for the last few years—and are intended primarily for various other studies on the subject of embryology, growth, and physical development of the Filipinos.

The study of the thymus in the first group was made after the bodies had been embalmed to provide sufficient hardening of tissues and organs indispensable for the exact topographical study of the gland and to insure certain fixed points of reference in these specimens during the process of tracing and graphic reconstruction as recommended by Scammon in the use of his graphic reconstruction apparatus. The studies that were followed over the second and third series of cases, however, were all done in necropsy when the specimens were yet fresh and unembalmed. These cases were those received in the City Morgue from all parts of the city and were autopsied within forty-eight hours after death. Adequate mathematical computations and the necessary quantitative determinations were made and allowances given in determining the ponderal and dimensional conditions of the thymus when fresh, on the one hand; and when preserved, on the other, for the necessary comparative standing of the data derived from the three series. The details of the process of this computation have purposely been omitted in this report.

The embalming fluid used in all the preserved specimens is 10 per cent aqueous solution of formaldehyde injected into the great vessels of the thigh and neck. This same solution is used in the preservation tanks wherein all our specimens are immersed and kept.

In exposing the thymus there were reflected primarily the skin, subcutaneous tissues, and superficial musculatures of the anterior surfaces of the neck and chest. Several definite points of reference were first determined and securely designated by long pins through the chest. A complete tracing of the exposed cartilagenous and bony framework of the chest was then made on coördinate paper, under the reconstruction glass platform of

Scammon's reconstruction apparatus with the aid of his tracing ocular (Plate 1). Once this was completed, the entire anterior bony and cartilagenous framework of the breast (the sternum, costal cartilages, clavicles, and ribs) was detached by lateral incisions along the mid-clavicular and anterior axillary lines of both sides. The sternomastoid and infrahyoid muscles were dissected and reflected upward. After this dissection, there were naturally exposed the anterior mediastinum and part of the pleural cavities on each side containing the lungs, together with the larynx, thyroid and thymus glands, and the pericardium as they were seen from the anterior aspect. By the same procedure, an accurate outline tracing of the gland was then made on the same tracing of the bony framework of the thorax. All the twenty-nine cases of newborns belonging to the first series were traced and plotted identically in this manner. All the tracings were made after the important stage of dissection was finished. This is done for the purpose of studying closely the exact topographical position of the thymus in reference to the other structures of the neck and trunk closely related to it. The various dimensions of the organ were then taken with fine-pointed calipers to ten-hundredths of a millimeter. The posterior topographic relations of the organ were then exposed and traced on the tracings already made of the superficial structures and thymus.

The author desires to acknowledge, in this connection, the valuable help rendered by Dr. Braulio Borlaza in doing some of the initial dissection of our cases at the beginning of our work. Doctor Borlaza was formerly an instructor in the Department. His stay with us was cut short by his unexpected sickness, hence his valuable assistance in this particular line of investigation was early interrupted.

RELATIONS, POSITION, AND FORM OF THE THYMUS

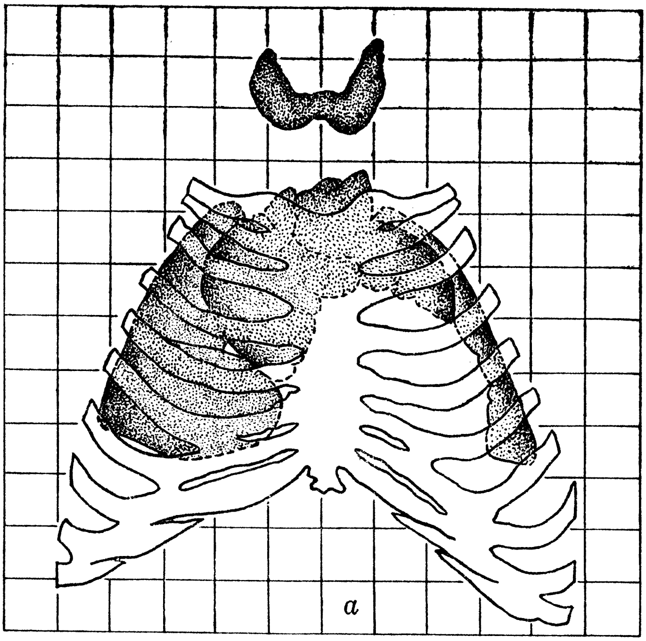
In the fresh condition the thymus is pale grayish pink, soft in consistency, slightly less resistant than the atelectatic lung of the newborn, and molds itself to the surrounding structures quite easily. Under such conditions, the dimensional measurements and the topographic determination of the position of the gland are not securely obtained—hence, fixation in situ is advisable before such observations are recorded.

The immediate relations of the thymus vary slightly with its size and shape. The extent of its contact with other structures in the mediastinum depends upon various factors; such as, the

degree of growth of the organ itself, the extent of the medial expansion of the lungs on either side, and the relative inclination and expansion of the heart at the postero-inferior side of the thymus. The manubrium and the upper part of the body of the sternum are immediately anterior to the gland as also frequently are the cartilages of the first three ribs, and even of the fourth and fifth, occasionally. The extent of their contact depends upon the limits of the transverse diameter of the thymus, which may reach from 0.5 to 1.5 centimeters beyond the lateral borders of the sternum. The cervical portion of the thymus is covered anteriorly by the sternohyoid and sternothyroid muscles with the deep cervical fascia intervening between. It rises as high as 2 centimeters above the superior border of the manubrium. Posterior to the thymus are found the left innominate vein, which obliquely crosses it; the inferior thyroid vein, and the inferior vena cava. Lower, and also in contact with the thymus, is the pericardium, which covers the atria, the arch of the aorta, and the trunk of the pulmonary artery. Part of the pericardium covering the right ventricle of the heart is also overlapped by the inferior border of the thymus, especially when the gland is elongated in shape and when lower in position. The posterior relations of the cervical portion are the trachea, the branches of the inferior thyroid vein, and the thyroidea ima. On each side, the lateral borders of the thymus are also in contact with the mediastinal reflections of the pleura, which are occupied inside by the anterior edges of the lungs. These structures tend to encroach and press upon the lateral edges of the thymus medialward for a varying extent in the cases wherein the inspiratory distention has already been established.

Text figs. 1 and 2 are taken directly from the reconstruction tracings. They show the anterior and posterior relations of the thymus—fig. 1 in a fœtus that has not yet breathed and fig. 2 in a fœtus that has had respiration established.

From actual observation in the process of autopsy and dissection of our cases of over three hundred children, we did not find a single instance of enlarged thymus sufficient in volume to produce actual pressure obstruction against the surrounding structures. Such a condition has been frequently mentioned and attributed to this organ to help explain in many cases certain disturbances associated with respiratory difficulties in infants and young children. In fact the thymus appeared to us too soft when fresh, with an easily molding consistency, to produce



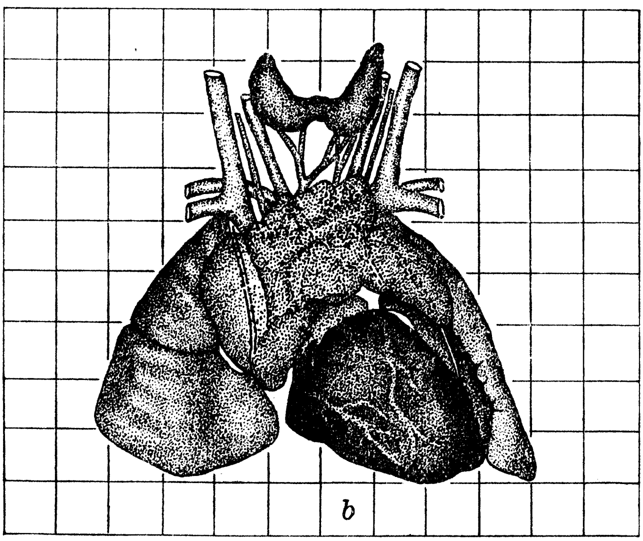


FIG. 1. **Relations and topography of the thymus in a fœtus that has not yet breathed (case 24); *a*, anterior relations; *b*, posterior relations.**

stenosis or pressure obstruction against the tracheobronchial tree and the lungs. What we have actually found is rather the reverse; that is, the pressure against the thymus resulting from

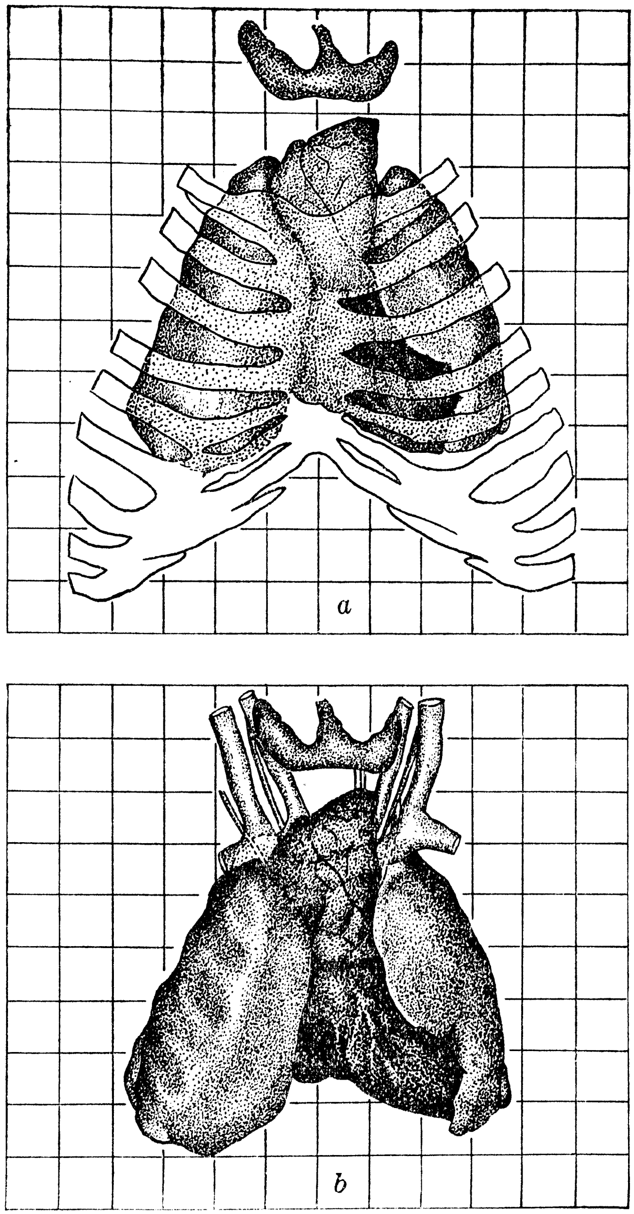


FIG. 2. Relations and topography of the thymus in a newborn that has had respiration established (case 22); *a*, anterior relations; *b*, posterior relations.

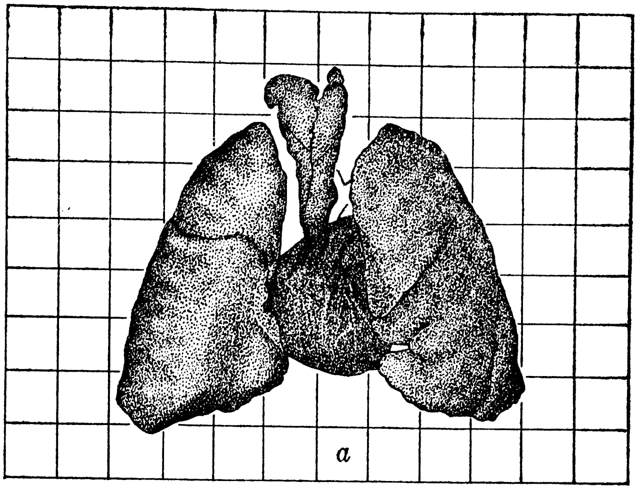
the expansion of the lungs was sufficiently effective to crowd the gland medially, and this is undoubtedly responsible for the production of the elongated form of thymus in children in

whom the respiratory function has been fully established. This condition will be described more in detail, presently, in the description of the position of this organ.

In regard to the position of the gland, we have observed that there is a preponderance of the thoracocervical location of the thymus in Filipino newborn children. This position has the greater portion of the gland in the thorax and the lesser part in the lower cervical region. This condition was found in 86.2 per cent of our newborn cases. On the other hand, the cervicothoracic position, where the main part of the gland is found in the cervical region and the lesser part in the thorax, was met with in only 6.9 per cent of our cases. The exclusively thoracic position of the thymus in our series was also found in 6.9 per cent of cases. There has not been seen a single case of newborn where the thymus was exclusively located in the neck.

In older children and young adults the exclusive thoracic position of the thymus was the one found with greater frequency. In the adolescent stage it was seen that a considerable number, around 65 per cent of cases, were of the exclusively thoracic location. In children around 5 years of age, however, the thoracocervical position of the organ still predominates, the frequency reaching about 72 per cent. These findings seem to indicate that with the normal growth-process of elongation of the neck and extension of the head, together with the expansion of the thorax from infancy to the adolescent stage, there exists collaterally a shifting of position of the thymus from the cervical to the thoracic region. This is probably effected, in one way or another, by such influences as organic pressure and tissue traction resulting from growth and changes of position of neighboring organs and structures in response to the alterations of the attitude of the head and thorax together with the direct influence of gravity. It is to be remembered that the condition of kinetic and dynamic tissue growth and expansion at this period of development, is in its highest expression. In fact the change of position of the thymus must be regarded as one of the many examples of the occurrence of such normal phenomena in the body.

A considerable range of variation was found in the form and shape of the thymus. The form is primarily and fundamentally influenced by the number of lobations of the organ during embryonic life, and secondarily, during the fœtal stage, by the effect of immediate contact or actual pressure exerted by the neighboring organs against the gland, more particularly by those actively moving or expanding organs of the thorax. The



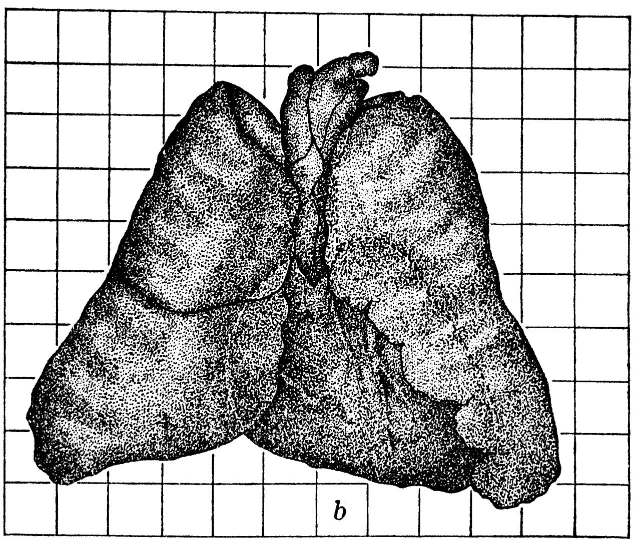


FIG. 3. Two typical forms of elongated thymus as produced by the pressure expansion of the lungs; *a*, case 7; *b*, case 18.

thymus may, of course, attain in its very early development, a unilobular, bilobular, and trilobular condition. If the division of the lobes is imperfectly attained or there is an apparent tendency of the lobes to fuse, this form is classified as conglomerate. Text fig. 4 represents the different forms of thymus as we have found them in situ. In our newborn series the bilobed condition of the organ reaches a frequency of 48.3 per cent. That of the conglomerate type is found in 34.5 per cent

of cases, while the trilobed condition is met with in only 17.2 per cent. If the transverse diameter of the whole organ is longer than the vertical diameter this is known as broad thymus. If the latter measurement, on the other hand, is longer than the transverse diameter, this type is known as elongated thymus. It was found in our series of newborns as similarly described by others for other races that the pressure exerted by the expanding lungs, encroaching on each side of the thymus, had much to do in determining the ultimate shape of this gland. It was obvious that there was a tendency for the anterior borders of the two lungs to press and crowd the lateral borders of the thymus towards the median line at the onset of active respiration. This pressure would naturally help reduce the transverse diameter of the gland, producing thereby an elongated type of thymus in many infants examined. What seemed to have happened in many instances at the beginning of the respiratory expansion of the lungs was the primary anterior overlapping of the lateral part of the thymus by the anteromedial edges of the lungs. This overlapping was in fact one of the most noticeable invariable signs of established respiration in all of our fœtuses that had already breathed. (See Table 3, the résumé of the series of twenty-nine fœtuses.) In older children, the constant encroachment and pressure by the lungs has produced permanent pressure-marks against the lateral sides of the thymus, thereby helping it to retain its elongated narrow position in the middle portion of the anterior mediastinum. Text fig. 3, *a* and *b*, shows two typical forms of this elongated thymus as produced by the pressure-expansion of the two lungs. (Cases 7 and 18, respectively.)

SIZE AND WEIGHT OF THE THYMUS IN THE NEWBORNS

The mean weight of the thymus for the male full-term newborns is 8.1 grams. The maximum weight observed is 16.2 and the minimum is 0.9 gram. For the female newborns the mean weight is 5.5 grams, with the maximum and minimum weights 11.3 grams and 0.9 gram, respectively. The two extremes of the weight of the thymus found for the two sexes show that there exists a wide extent of variation in the ponderal condition of this organ in Filipino newborns. We have observed this condition very early in our necropsies of these children and it appealed to us as indicating that the great degree of variation existing in the state of nutrition and body weight of these children may really have been responsible for the wide ponderal

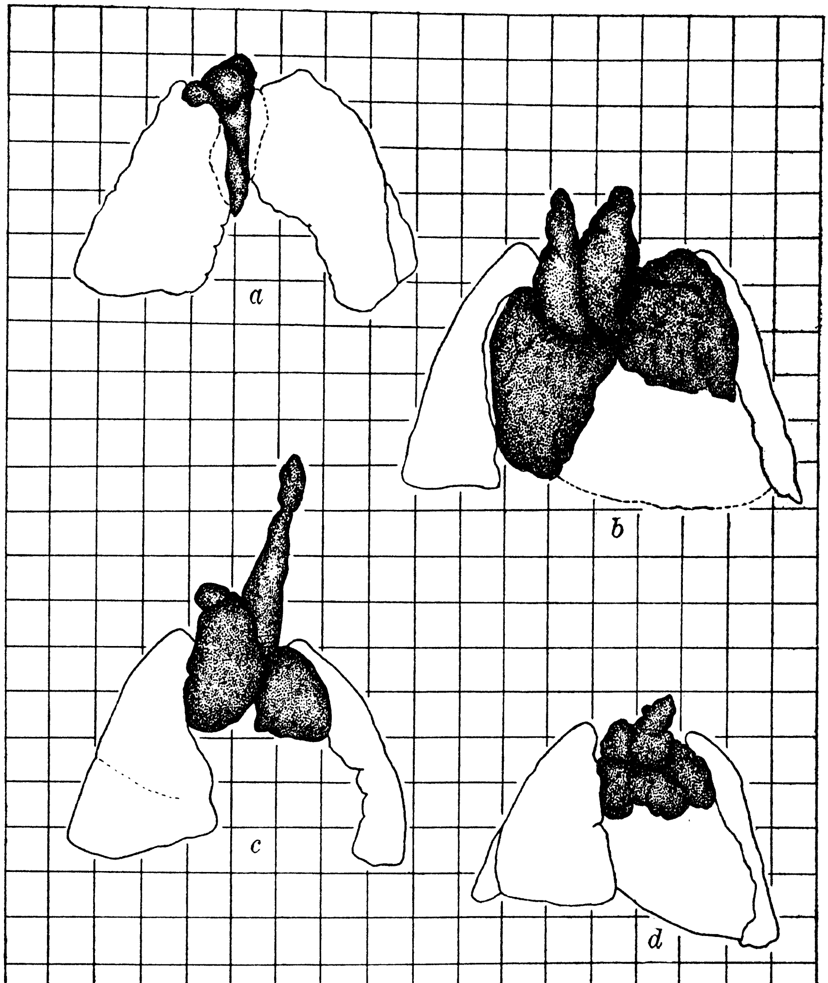


FIG. 4. Different forms and shapes of the thymus; *a*, unilobar type, case 20; *b*, bilobar type, case 9; *c*, trilobar type, case 16; *d*, conglomerate type, case 23.

variation of the thymus observed. This will be discussed further in the latter part of this paper.

The dimensions of the thymus for the male newborn give the mean values of 43.7 and 36.6 millimeters for the length of the right and left sides, respectively; 37.5 millimeters for the mean breadth and 14.0 millimeters for the mean thickness. The maximum and minimum ranges of these dimensions are given in detail in Table 1. In the female newborn the mean lengths of the right and left sides of the gland are, respectively, 28.4 and 30.0 millimeters. The mean width found is 34.0 millimeters and

TABLE 1.—*Mean, maximum, and minimum values of body measurements and dimensions, weight, and module of the thymus with their highest frequency distribution in Filipino newborns (series of 29 cases).*

MALE SERIES.

Measurements.	Mean.	Maximum.	Minimum.	Range of highest frequency.	
				Actual value.	Per cent.
Standing height .... cm..	43.1	33.0	37.0	35- 45	75.0
Sitting height .... cm..	28.8	36.0	24.5	26- 28	43.7
Body weight .... g..	2,319.8	3,743.0	1,573.0	1,500-2,500	75.0
Body volume .... cc..	2,269.1	3,650.0	1,450.0	2,000-2,400	37.5
Circumference of thorax .... cm..	28.7	34.5	24.0	24- 28	50.0
Circumference of head ...... cm..	31.5	36.0	28.0	28- 32	75.0
Measurements of thymus:					
Weight .... g..	8.1	16.2	0.9	0.5- 10	75.0
Length—					
Right side .... mm..	43.7	71.0	28.0	....	....
Left side .... mm..	38.6	69.0	22.0	....	....
Breadth .... mm..	37.5	61.0	16.0	....	....
Thickness .... mm..	14.0	44.0	8.0	....	....
Module	30.6	52.6	18.5	25- 35	56.3
FEMALE SERIES.					
Standing height .... cm..	42.0	52.0	37.5	35- 45	84.6
Sitting height .... cm..	27.8	34.7	24.5	24- 26	38.4
Body weight .... g..	2,036.0	3,744.0	1,180.0	1,000-2,000	61.5
Body volume .... cc..	1,972.3	3,650.0	1,120.0	1,200-2,000	61.5
Circumference of thorax .... cm..	28.2	37.0	22.8	23- 31	61.5
Circumference of head ...... cm..	31.6	42.0	25.0	26- 34	69.2
Measurements of thymus:					
Weight .... g..	5.5	11.3	0.9	0.5- 10	84.6
Length—					
Right side .... mm..	28.4	39.0	18.0	....	....
Left side .... mm..	30.0	38.0	19.0	....	....
Breadth .... mm..	34.0	58.0	14.0	....	....
Thickness .... mm..	13.0	54.0	2.0	....	....
Module	26.2	36.0	17.3	15- 20	38.4

the mean thickness is 13.0 millimeters. Therefore, there is seen, relatively, a smaller size of thymus in the female than in the male in corresponding parallel to the lesser mean weight of the organ in the former. From the comparative standing of the maximum and minimum values of the various dimensions of the thymus, as shown in Table 1, it is noticed that there is wider variation in the thickness than in the breadth, and that in the latter dimension there is also a greater variation than is found in the mean length of the organ. These relative con-

ditions of variations in the three dimensions of the gland are true for both the male and the female newborns of our series.

TABLE 2.—*Frequency distribution of standing height of newborns with the actual averages of sitting height, body weight, and volume and the weight and module of the thymus (series of 29 cases).*

Standing height.		Cases.	Frequency.	Sitting height, average.	Body weight, average.	Body volume, average.	Thymus.	
Range.	Average.						Weight.	Module.
cm.	*cm.*		*P. ct.*	*cm.*	*g.*	*cc.*		
35–40	34.8	10	34.5	26.0	1,635	1,572	4.3	25.4
40–50	42.7	13	44.9	27.9	2,100	2,060	6.3	29.2
45–50	47.9	3	10.3	32.0	3,023	2,583	10.7	33.4
50–55	52.3	3	10.3	34.5	3,623	3,566	8.7	33.3
Total		29	100					
Mean value for the series				30.1	2,595	2,445	7.5	30.1

The mean value of the module of the different dimensions of the thymus of the newborns is 30.6 millimeters for the male and 26.2 millimeters for the female. The maximum and minimum module values recorded are, respectively, 52.6 and 18.5 millimeters for the male and 36.0 and 17.3 millimeters for the female. These figures further show correlatively the existence of a relatively smaller size of the gland in the female group.

It is also to be mentioned, in connection with the last point, that there is invariably shown in all the body measurements taken of these newborns, the presence of a lower condition of mean values in the females, both in dimensions and in weights. Thus, in the standing and sitting heights of these fœtuses the values for the male are, respectively, 43.1 and 28.8 centimeters, whereas in the female they are, respectively, 42.0 and 27.8 centimeters. In the body weight and body volume the mean values are, respectively, 2,319.8 grams and 2,269.1 cubic centimeters for the male; while they are, respectively, 2,036 grams and 1,972.3 cubic centimeters for the female. Even in the position of the highest frequency group of these various measurements as shown in Table 1, there exist likewise relatively lower linear, ponderal, and volumetric values for the female series.

The highest values of frequency distribution of the various measurements of the thymus in the series of twenty-nine cases are given in Table 2, and the complete record of measurements of each case in the group is found in Table 3.

TABLE 3.—*Complete record of measurements of the 29 cases of newborns with thymus carefully dissected, traced, and measured, and relations recorded.*[a]

Serial No.	Number.	Standing height.	Sitting height.	Sex.	Body weight.	Body volume.	Circumference, thorax.	Circumference, head.	Thymus.									Lungs expanded or not.	Thymus overlapped or not.	
									Form.	Lobes.	Position.	Weight.	Length.		Breadth.	Thickness.	Module.			
													R	L					R	L
		cm.	*cm.*		*g.*	*cc.*	*cm.*	*cm.*				*g.*			*mm.*	*mm.*				
1	6	36.0	25.5	M	1,600	1,450	24.5	29.0	E	Bi	Tc	3.3	37	31	27	8	23.0	+	+	+
2	28	36.5	26.5	M	1,573	1,565	24.0	28.0	B	Bi	Tc	7.4	29	38	34	15	27.5	+	—	—
3	11	37.0	24.5	M	1,653	1,600	26.0	31.5	Eb	Tri	Tc	4.4	48	23	44	9	29.5	—	—	—
4	10	37.5	25.5	F	1,342	1,310	25.0	27.0	B	Bi	T	5.6	31	31	42	11	28.0	+	+	—
5	8	38.0	24.5	F	1,368	1,350	24.5	25.0	Bb	Bi	Tc	0.9	18	20	32	4	18.3	—	—	—
6	23	38.3	26.7	F	1,851	1,800	26.8	31.6	Bb	Co	Tc	2.2	27	19	25	8	18.7	+	+	+
7	1	39.0	26.5	F	1,180	1,120	22.8	30.5	B	Co	Tc	1.3	20	21	25	8	19.8	+	+	+
8	4	39.5	25.8	F	1,820	1,600	27.0	29.5	B	Co	Tc	8.3	34	38	43	13	30.6	+	+	—
9	19	39.5	27.3	M	1,910	1,900	27.4	30.8	E	Co	Tc	2.7	40	31	34	11	26.8	+	+	+
10	16	39.5	27.5	M	2,055	2,030	28.5	30.5	E	Tri	Tc	6.8	32	64	34	14	32.0	+	—	—
11	5	40.0	25.0	F	1,477	1,450	19.5	29.0	Bb	Bi	Tc	3.6	22	31	41	7	24.8	—	—	—
12	15	41.0	26.0	F	1,733	1,700	26.0	29.5	B	Bi	Tc	8.6	39	38	45	14	32.5	—	—	—
13	21	41.8	26.7	M	2,030	2,050	28.2	31.9	EB	Bi	Tc	9.6	52	46	44	11	34.6	—	—	—
14	24	41.8	28.2	M	2,404	2,350	29.8	32.5	Bb	Bi	Tc	10.4	39	31	48	18	33.6	—	—	—
15	7	42.0	28.0	M	1,645	1,600	25.5	30.0	En	Co	Ct	0.9	35	22	16	11	18.5	+	—	—
16	26	42.5	28.5	M	2,188	2,100	27.8	29.8	B	Bi	Tc	11.9	71	69	44	44	52.6	+	+	+
17	14	43.0	28.5	F	2,037	1,980	37.0	42.0	En	Co	Tc	1.9	30	35	16	10	19.5	+	+	+
18	22	43.4	29.2	M	2,320	2,320	30.1	31.3	E	Co	Ct	2.8	28	26	22	8	19.0	+	—	—
19	20	43.4	28.5	F	1,772	1,780	28.2	31.2	En	Co	Tc	1.9	29	29	21	2	17.3	+	+	+
20	29	43.5	28.0	F	3,017	2,950	33.5	33.2	Bb	Bi	Tc	11.3	34	37	14	54	34.5	—	—	—
21	3	44.0	27.5	M	2,227	2,150	28.0	30.5	E	Tri	Tc	7.8	43	48	39	11	31.8	+	+	+
22	13	44.0	28.0	M	1,975	1,950	27.2	31.0	Eb	Bi	Tc	3.5	35	30	32	8	24.1	+	+	+

23	17	45.0	31.0	F	2,470	2,400	29.5	33.0	B	Tri	Tc	8.1	26	32	58	18	36.6	+	+	+
24	27	46.5	31.5	F	2,657	2,550	30.5	34.3	Bb	Tri	T	6.8	31	29	46	8	28.0	+	+	—
25	2	47.3	32.5	M	2,670	2,550	30.2	31.8	E	Bi	Tc	9.1	29	44	32	21	29.8	+	+	+
26	9	50.0	32.0	M	3,743	3,650	34.0	36.0	Eb	Bi	Tc	16.2	64	47	57	15	42.5	+	+	—
27	12	52.0	33.0	M	3,670	3,600	34.5	34.5	Eb	Bi	Tc	14.0	65	54	61	9	43.1	+	—	—
28	25	52.0	34.7	M	3,744	3,650	36.4	36.2	E	Co	Tc	10.7	54	31	50	12	34.8	+	—	—
29	18	53.0	36.0	M	3,455	3,450	33.4	35.5	En	Co	Tc	1.5	42	22	21	13	22.0	+	+	+

[a] Frequency of types: Bi, 14, or 48.27 per cent; Tri, 5, or 17.24 per cent; Cong, 10, or 34.49 per cent. Frequency of position: Ct, 2, or 6.9 per cent; Tc, 25, or 86.2 per cent; T, 2, or 6.9 per cent.

The ponderal and dimensional states of the thymus in the second series of newborns—those that lived up to the second day of life (consisting of 164 cases)—have consistently shown slightly higher values when compared with those obtained from the first series—cases who died during or soon after delivery (29 cases). Table 4 represents the actual distribution of the series grouping of the one hundred sixty-four cases showing the weight and module of dimensions of the thymus, together with the sitting height and body weight of the group. It will be observed that approximately 60 per cent of this series are within the standing height group of 40 to 50 centimeters, with the rest falling more below than above this height interval. A parallel comparison of these data with the records of measurements gathered from the first series, as given in Table 2, has shown that although in body weight those of the second series are generally lower by approximately 200 grams, yet in the weight and module of the thymus, they are consistently heavier and slightly larger. In fact, the weight of the thymus in the second series is from 30 to almost 100 per cent greater than that in the first group. In reference to the module of dimensions of the gland, although it is also relatively higher in this series, the existing difference is not as great as in the case of weight. All these comparative findings are readily seen by comparing Tables 2 and 4.

TABLE 4.—*Frequency distribution of standing height, with the group averages of sitting height, body weight, and the weight and module of the thymus in newborns (series of 164 cases).*

Standing height.		Cases.	Frequency.	Sitting height.	Body weight.	Thymus.	
Grouping.	Average.					Weight.	Module.
cm.	*cm.*		*P. ct.*	*cm.*	*g.*	*g.*	*mm.*
30–35	33.7	18	19.98	24.0	946	8.8	20.8
35–40	38.4	20	12.19	27.3	1,314	8.1	27.2
40–45	43.0	52	31.71	30.6	1,851	11.4	32.1
45–50	47.8	45	27.44	34.0	2,623	15.3	36.1
50–55	52.4	21	12.80	37.4	2,995	14.8	37.1
55–60	57.8	4	2.44	38.1	3,848	10.2	34.7
60–65							
65–70	68.5	2	1.22	46.5	5,057	10.0	16.8
70–75	72.0	2	1.22	45.0	5,312	4.0	19.1
Total		164	100				
Mean values for the series				31.7	2,172	12.4	32.0

TABLE 5.—*Comparative table of averages of the height and weight of the body and the weight and module of the thymus from the two series of newborns and their mean averages.*

	Standing height.	Sitting height.	Body weight.	Thymus.	
				Weight.	Module.
	cm.	*cm.*	*g.*	*g.*	*mm.*
Series of 29 cases	41.4	30.1	2,595	6.8	30.1
Series of 164 cases	44.9	31.7	2,172	12.4	32.0
Mean average of 193 newborns.	43.1	30.9	2,383	9.6	31.0

Such an unparalleled condition of the weight of the body on the one hand and of the weight of the thymus on the other in our two groups of newborns appear to us as probably due to the actual occurrence of that generally observed condition of initial loss of body fluid noticed soon after delivery. This postnatal loss within the first two days of life must have been the contributory factor that determined the lowering of the body weight in the cases of our second group. Whereas the body weight in the first series has been taken immediately after delivery and before the initial loss of fluid could have taken place, that of the second series was taken from several hours to two days after birth, certainly after some amount of body fluid must have been already eliminated. The thymus has not appeared to be affected at all by this process of loss of body fluid, as evidenced by our findings that neither in weight nor in dimensions the gland showed appreciable decrease. In all probabilities this organ, like the other ductless and nonexcretory organs in the body, ordinarily does not lose fluid after birth. On the other hand it seems quite true that the thymus continued to undergo a rather rapid postnatal growth and that the difference in weight noted between our two series of newborns, expresses the ponderal rate of growth of this gland from the time of birth up to the second day of life.

In the light of these findings it appears quite obvious that the thymus undergoes a fairly rapid growth or increased expansion in size within the first two days of extra-uterine life. Whether this is due to an actual proliferation and growth of the cellular elements of the gland or rather to the increased blood supply or to an accelerated circulation of the blood within the substance of the organ, we cannot very well tell until more-

comprehensive histological studies are made. At any rate, there seems to be sufficient indications to consider the above conditions as tangible expressions of the relative functional importance of this endocrine gland at this period of postnatal development.

Summarizing the ponderal and dimensional findings here noted as obtained from the two series of newborns of one hundred ninety-three cases, both male and female, as given together in Table 5, we have as follows: Standing height, 43.1 centimeters; sitting height, 30.9 centimeters; body weight, 2,383 grams; weight of thymus, 9.6 grams; module of the thymus, 31 centimeters.

SIZE AND WEIGHT OF THE THYMUS IN YOUNG CHILDREN AND ADOLESCENTS

Our records of measurements for older children are summarized in Table 6. It is regretted that we do not have a greater number of cases for the older series reported here. It will be seen from this table that cases over 100 centimeters in crown to heel length (approximately from the fifth year of age up) are not over twenty-four in number, and that their serial distribution runs from two to eight cases only. We fear that the number gathered for the age beyond the second year of life may not be comprehensive enough to warrant more than tentative conclusions. We are, therefore, presenting our observations and findings on this series as preliminary reports only, subject to revision when more material may be gathered and studied. It has been our experience for many years now that only a few pauper cases of older children and even much less of the age nearing adolescence, reach the City Morgue, where most of our cases are collected. So, necessarily our studies on the postnatal development of the internal organs find some interruptions at this age and more particularly at the preadolescent period of life.

As observed from Table 6, there takes place a gradual, though somewhat irregular, increase in the weight of the thymus from birth up to the standing height of 100 centimeters. At this stage the weight of the organ of the infant is already double that at birth. In the group between the standing height of 90 and 100 centimeters, corresponding, approximately, to the age

of 4.5 years, and in that between the height of 120 and 130 centimeters, corresponding to the ages of 8 to 11 years, there are seen considerably more ponderal increases in the weight of the thymus, reaching as much as 15.5 grams for the former group, and 31.1 grams for the latter. These marked increases, particularly that in the younger group, may probably be attributed to the variation in sampling of limited cases and may carry no developmental significance. On the other hand, they may really denote the true conditions in which this organ is found during these two age intervals. We will refer to this point again more in detail in an appropriate section of our discussion of the subject.

TABLE 6.—*Frequency distribution of standing height with the actual averages of age, weight of the body, and weight of the thymus in the cases that have lived from the second day up to the fifteenth year of life (series of 145 cases).*

Standing height.		Cases.	Frequency.	Age.		Average body weight.	Average thymus weight.
Grouping.	Average.			Limits.	Average.		
cm.	*cm.*		*P. ct.*			*g.*	*g.*
40– 50	45.7	22	13.8	2 days to 2 months	1.5 months	2,552	5.62
50– 60	55.0	34	23.4	1.5 to 13 months	3.8 months	3,373	4.78
60– 70	65.1	21	14.5	3.5 to 18 months	9.2 months	5,305	7.33
70– 80	75.6	20	13.8	9.0 to 36 months	26.0 months	6,791	6.17
80– 90	85.3	13	9.0	1.5 to 4 years	2.6 years	8,862	9.31
90–100	95.0	11	7.6	3.0 to 7 years	4.4 years	11,371	15.54
100–110	107.6	3	2.1	5 to 7 years	6.3 years	14,400	11.67
110–120	117.0	2	1.4	7 to 8 years	7.5 years	17,525	10.10
120–130	126–1	6	4.1	8 to 11 years	9.7 years	21,898	31.14
130–140	135.0	8	5.5	12 to 15 years	13.1 years	25,788	19.71
140–150	143.0	3	2.7	12 to 15 years	13.7 years	33,000	19.11
150–160	154.5	2	2.1	13 to 15 years	14.3 years	41,907	17.81
Total		145	100				

In the oldest and last three age groups of the table there appears to be a continuous increase in growth of the thymus, although in a relatively lesser degree than in the previous stages. It is noticed that at a standing height of 126 centimeters, corresponding to the age of about 9.5 years, the weight of the thymus is already four times that at birth. This ponderal condition remains uniformly sustained excepting only for a very slight retardation in one instance in the group, in the stage of 160 centimeters height, corresponding to the age of 15 years. The

rather abrupt increase in weight at the standing height of 126 centimeters may be interpreted as a heightened state of growth at that age with a probable collateral increase in the internal secretory function of the gland. It is, of course, known that at this age, especially in the male, the developmental processes of the body, more particularly in reference to longitudinal dimensions of body segments, are most rapid and that it is at this period of life precisely when the epiphysial ends of long bones lengthen the most. It may be possible that the highest normal activity of the thymus is exerted at this period of development. It is noticed also from the same table that the stages following this exacerbation in the increase of weight of the organ there is initiated a period of stationary or even of very slight decrease in the ponderal state of the gland, continuing and extending to the cases with a standing height of 154 centimeters, or approximately the age of 15 years, the highest age limit of this series.

TABLE 7.—*Summary table of measurements from all the series of cases (338) together with the percentage of the weight of the thymus to the body weight.*

Standing height.		Cases.	Body weight.	Thymus weight.	Percentage weight of thymus to body weight.
Grouping.	Average.				
cm.	*cm.*		*g.*	*g.*	
30- 40	35.6	48	1,298	7.06	0.543
40- 50	45.4	135	2,428	9.86	0.406
50- 60	54.3	62	3,459	9.62	0.278
60- 70	66.8	23	5,190	8.66	0.166
70- 80	73.6	22	6,051	5.08	0.083
80- 90	85.3	13	8,862	9.31	0.105
90-100	95.0	11	11,371	15.54	0.136
100-110	107.6	3	14,400	11.67	0.081
110-120	117.0	2	17,525	10.10	0.057
120-130	126.1	6	21,898	31.14	0.142
130-140	135.0	8	25,788	19.71	0.076
140-150	143.0	3	33,000	19.11	0.057
150-160	154.5	2	41,907	17.81	0.042

The ponderal state of the thymus when compared with the body weight shows a decreasing growth ratio from the time of birth up to the fifteenth year. Such a disproportionate condition of growth between the two is shown in percentage basis

in Table 7, and graphically presented in fig. 5. It is obvious from the table that the growth of the body in terms of weight, which is quite fundamental, advances much more rapidly than the weight of the thymus after birth and that this lagging is still greater as adolescence is approached. Thus, at the standing height of 30 to 40 centimeters, the proportion of the weight of the thymus to the weight of the body is around 0.54 per cent; at the height of 90 to 100 centimeters, its percentage relation to the body weight is only about 0.13 per cent, and at the height of 150 to 160 centimeters this proportion has dropped to 0.04 per cent. Of course, it is generally known, although not yet fully accepted, that the absolute weight of the thymus increases quite rapidly until the third year of life and is supposed to change but slightly to the seventh year, when the organ again starts gradually increasing in weight until the eleventh year. From this time the weight and dimensions of the organ are known to decrease rapidly. This course of growth is believed to be true for both sexes, only that at the eleventh year the gland is found to be larger in the female. In the present study we could not determine precisely and specifically these varying ponderal conditions of the thymus as observed in different ages, doubtless because of the limited number of cases studied in our series, which unfortunately cannot offer a fair number of age distribution throughout our age groupings. We have observed, however, that in our series there is an abrupt increase in the weight of the thymus at the standing height of 126 centimeters, approximately corresponding to the age of 9.5 years; and that following this rapid increase there is also a stationary or even a slight decrease in weight of the organ until the fifteenth year. We may presume from this that it may be possible that, with the distinctly different series we are dealing with the precise age period of rapid exacerbation of increased weight of the thymus, which normally happens at the seventh year of life in Caucasian children of temperate regions, may really occur at the ninth year of age in our children of Malayan stock and living in a tropical country. However, this presumption needs further study and verification through more-extensive observations of a larger and more-comprehensive series of cases. For the present we leave this tentative assumption as an open question subject to further study.

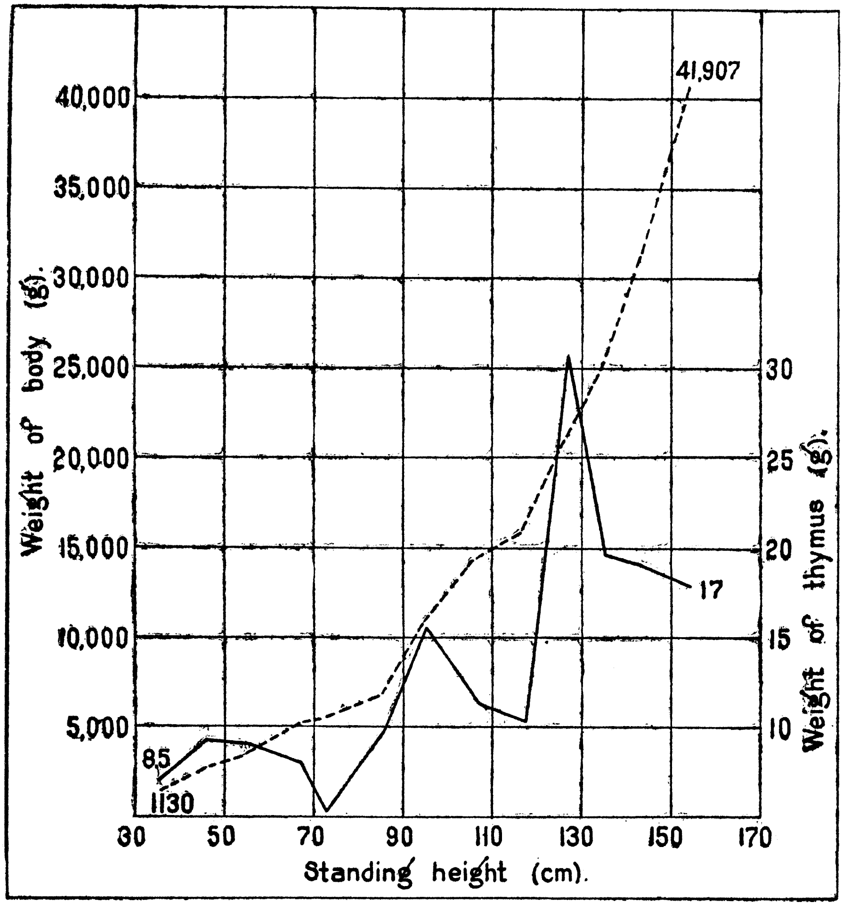


FIG. 5. Ponderal rate of growth of the body and the thymus from the time of birth to the fifteenth year of age.

VARIATIONS OF THE WEIGHT OF THE THYMUS WITH CHANGES IN BODY WEIGHT

Previously we have emphasized the finding that there exists a wide extent of variation in the ponderal state of the thymus in our series of newborns and that there is also observed, in apparent direct relation with this, a similarly wide degree of fluctuation in the body weight of our cases. To understand more clearly what direct bearing these two observations have on one another, we segregated the newborn cases into two groups of distinct body weights—one group of nonemaciated cases having body weights above 2,000 grams, and another group of poorly nourished newborns whose body weights were less than

2,000 grams. The relative standing of these two groups in their ponderal qualities are given in Tables 8 and 9. It is clearly demonstrated in these tables that in both series of newborns (series of 29 and 164) those possessing body weights of more than 2,000 grams almost invariably possess also larger and heavier thymuses than those belonging to the emaciated group. This is true not only for the mean ponderal values but also for the minimum and maximum records of weights. These two tables give for both weight and module of the thymus their minimum, mean, and maximum values, all of which invariably follow the same parallel fluctuations observed between the emaciated and nonemaciated groups.

TABLE 8.—*Average weight and module of the thymus in the nonemaciated newborns (body weight above 2,000 grams).*

Series.	Body weight.			Weight of thymus.			Module of thymus.		
	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.
Series of 29 cases (16 cases)	2,030	2,712	3,744	1.5	10.2	28.0	19.0	32.9	56.6
Series of 164 cases	2,003	2,593	3,600	3.0	16.1	45.0	18.3	35.9	51.0
Average values	2,016	2,652	3,372	2.2	13.1	36.5	18.6	34.4	51.8

TABLE 9.—*Average weight and module of the thymus in the emaciated newborns (body weight below 2,000 grams).*

Series.	Body weight.			Weight of thymus.			Module of thymus.		
	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.
Series of 29 cases (13 cases)	1,180	1,635	1,975	0.9	3.9	8.6	18.3	24.2	32.5
Series of 164 cases (103 cases).	577	1,418	1,994	1.0	9.5	27.0	8.3	28.0	46.6
Average values	878	1,526	1,983	1.0	6.7	17.8	13.3	26.1	39.5

The foregoing shows that whereas the mean weight and module of the thymus are, respectively, 13.1 grams and 34.4 centimeters for the nonemaciated newborns, they are 6.7 grams and 26.1 centimeters for the emaciated group. The discrepancy in the weight and dimensions between the two groups is obviously considerable. As to what actual condition of morphological differentiation and functional changes this means for the thymus, we cannot very well ascertain until further microscopical studies of the organ under varying condition of nutrition

are undertaken. Of course it may be presumed that this is due to certain varying changes in the amount of development of the stroma and probably also of the adipose tissue present in the gland. The influence of the latter, however, might be doubtful, for we have observed that in the newborn and in early childhood there is hardly any adipose tissue in the organ. Moreover, adipose tissue is known to make its appearance in the stroma of this gland rather late in childhood and its rapid increase occurs only when involution has set in, usually in the eleventh to the fifteenth year. It does not seem probable, therefore, that this would really explain the variation found in the ponderal condition of the thymus in the emaciated and nonemaciated groups.

Another explanation, which we are inclined to consider as more probable, refers directly to the question of nutrition itself. It seems to be generally admitted that the thymus plays a certain important part in the maintenance of normal nutrition during the period of growth to sexual maturity. It appears to be true also that nutrition affects the morphological and probably the functional activity of the thymus as well. It is most likely that the parallel loss or decrease in weight of the thymus in our emaciated group is due to the presence of a premature type of involution in the gland of these newborns. It is, of course, generally true that starvation in children produces acute involution of the thymus and that the condition found in our emaciated group may very likely be the result of a mild form of starvation—malnutrition—causing a correspondingly mild process of early involution, probably some degenerative changes of the parenchymatous and reticular components, expressed grossly in its reduced size and loss of weight.

Some authors have already pointed out the presence of fluctuations in the ponderal state of the thymus and that these were in the main accounted for by variations in the nutrition of the body as a whole. There is a general belief, not fully concurred in, that the thymus serves as a reserve storehouse for nutritive materials and that this reserve is called upon by the body during times of unusual need. Recent investigators have come to claim that the thymus is one of the important sources of nuclein supply of the body; that under a certain constitutional state, when a high demand of nuclein is needed, as in conditions of inanition, in the period of sexual development towards the approach of maturity, or in infection, etc., this gland suffers

a varying degree of involution. Under the reverse condition, on the other hand, as in overfeeding when an increased supply of nuclein is obtained from the food, there is a correspondingly increased size or enlargement of the thymus. It has also been observed collaterally that the thymus frequently showed the result of excessive loss of weight much more rapidly than the body as a whole, and that in many exhausting diseases the loss in weight of the gland is proportionately much more than the loss in body weight. All these important points seem to strengthen the explanation tentatively offered by us to account for the existing variations in weight of the thymus in the emaciated and nonemaciated groups of our series. Many of the collateral details mentioned must be of considerable interest and importance in the study and understanding of our cases, particularly in their direct relation to the problems of the malnutrition that is generally known to exist in a large percentage of our children and young adults. It is our purpose to follow this work with a microscopic study of the thymus and we trust we can throw further light on these particular points.

COMPARATIVE STUDY ON THE THYMUS

It is of some interest to understand the comparative standing of our data with those reported from similar studies on the topography, dimensions, and weight of the thymus in other races. It is regretted that little literature of foreign workers on this subject is available locally and that we cannot present in this paper a more satisfactory comparative study of the thymus. We especially wanted to have our data compared with those of the Chinese, with which race the Filipinos have considerable blood admixture, and those of the Japanese, another Oriental race, of similar physical makeup. Records for the Chinese are yet lacking, and it appears that no study on the thymus for the newborn and adolescent of that race has been reported. Studies on the thymus for the Japanese have been made, but we failed to locate any direct reference to these in local science libraries. Data from these two neighboring Oriental races would have provided interesting points of comparison with our own findings.

The weights of the thymus in the newborn as reported by various European and American observers are given below together with our own data for the Filipinos.

Weight of the thymus in the newborns, as reported by various workers.

	g.
Amado (Spanish n. b.)	10.5
Bovaird and Nicholl	6.0
Crochet (French n. b.)	3.0 – 5.0
Figueira (Portuguese n. b.)	3.62
Holler (German n. b.)	3.0
Haugsted (German n. b.)	8.0 –12.0
Heckel and Buhl	8.42
Jackson (American n. b.)	13.0
Koelliker and Friedleben (German n. b.)	13.7
Letulle	8.5
Merkel	16.0 –20.0
Nañagas (Filipino n. b.)	9.6
Oliver (Spanish n. b.)	4.0
Sappey (English n. b.)	3.0
Testut (French n. b.)	5.0

As may be noted in this list, there is a considerable variation in the weight of the thymus among the different races of people. This ranges from 3 to 20 grams, with the majority falling between 3 and 8 grams. The weight reported for the Germans alone ranges from 3 to 13.7 grams. That for the Spaniards is from 4 to 10.5 grams, and for the French from 3 to 5 grams. The American newborns, as reported by Jackson show a weight of 13 grams for this organ. Other American observers have also reported a similar weight, which is obviously more than the average weight found for the other races. The highest reported weight for the thymus, however, is that given by Merkel, which ranges between 16 and 20 grams. It appears to us that these figures seem to indicate, in one way at least, that newborns of homogenous peoples show a lesser degree in the range of variation of the weights of the organ than newborns of heterogenous races. Of course, this point is not new, but in our opinion it needs further observation and confirmation before it can reasonably be accepted as a final and definitive conclusion.

The average weight of the thymus for the newborn Filipinos as found by us is 9.6 grams. This is to a certain extent comparatively heavier than the majority reported for the average weight found in the other races. In view of such a finding that shows the presence of a heavier thymus in Filipinos on an average, may we not presume that if the gland really exerts an important influence over body weight at birth, as is generally claimed, this function would be exerted to greater advantage in Filipino newborns; that is, if we are to judge from the relatively heavier ponderal condition of the organ in our fœtuses?

However, from our general observations and actual measurements of body weights and dimensions of Filipinos, this expected correlation between the weight of the gland and the growth of the body was not encountered. Under such circumstances we must look for some causes to explain the absence of this kind of growth correlation in Filipinos. We hold that the environmental and nurtural factors for growth in Filipinos, and the relatively unfavorable sanitary influences generally affecting the race, are still in many ways detrimental to growth. That for this organ to effect its function of influencing proper growth in our group, it may be a constitutional necessity in the body to increase, in a proportionate manner, its size and weight in response or in counter action against these many unfavorable conditions for growth still met with in the Philippines.

This functional correlation between the growth-promoting organ of the body, on the one hand, and the body constitution as a whole, in their integrative relation with the many factors of environment and nurture, on the other, may in all probability help explain the relatively heavier and larger thymus in the newborn Filipinos. In a former paper of the writer's dealing with the subject of development he had occasion to emphasize the following point of direct relevance to this question, namely:

The findings seem to signify that the internal conditions for growth of the fetus inside the maternal womb of the Filipino mother, although probably not yet ideal, are much better than are the external factors, influences, and provisions for development after birth. Filipino infants enter the world with a much poorer condition of environment and more meager facilities for good body growth, much poorer we believe than those offered to children of other races, who, when matured, are taller and larger than the Filipinos. These conditions clearly signify that there still exist, though not to the same extent as in the past, unfavorable environmental influences and factors that seriously interfere or dangerously inhibit the full attainment of the proper adult height and dimensions in Filipinos. Although opportunities for better means of living appear to have been already initiated in the last decade, as shown by the actual improvement in the physique of the present generation, yet much remains to be studied in the way of providing those essential environmental and nurtural requisites that will effect the optimum condition of body constitution and build among the masses of our population. It has been definitely observed that our children, and even our young adults, when offered a more ideal environment and placed under more beneficial influences for the promotion of body growth and development of physique, invariably show, barring anomalous body conditions, marked increment in growth and greater range

of body reactions leading to alertness and efficiency and to the higher type of mental perception and response. Such reactions clearly evidence the presence of latent potentiality in Filipinos that has not as yet been given full freedom of expression in order to give the body its maximum growth and development. In other words, the constitutional growth and physical demands of the body in our race have not as yet been given their optimum opportunity, nurturally and environmentally, for the full attainment of dimensions and size, and our race at present is somewhat stunted physically by the many varied detrimental or unfavorable factors that affect growth and development.

With our present data we have observed that the percentage relation of the weight of the thymus to the body weight in our newborns is around 0.54 per cent. In late childhood this proportion is found to have dropped to 0.08 per cent, and at the age of adolescence it has reached 0.04 per cent of the body weight. Compared with the records from another race whose data, we regret to say are the only ones available to us for this purpose, we have found that at birth the Filipino infants possess a proportionately heavier thymus in relation to body weight than those reported by Jackson for the American newborns. Jackson's percentages for these are 0.42 for the newborns, 0.12 for late childhood, and 0.09 for adolescence. It appears then that in late childhood the Filipino children have a proportionately smaller thymus as compared with the Americans, approaching only about the same proportion found for the adolescent age of the latter, and this in spite of the fact that at birth the Filipinos have a proportionately heavier thymus in direct relation to body weight than the American newborns. Such a condition may, of course, mean the existence of a relatively more rapid rate of growth during late childhood and during adolescence in Filipinos than in Americans, or that the usual process of thymic involution might have set in earlier in our race. We must mention in this connection that the actual weight of the thymus at the age of puberty in our group is 17.8 grams, whereas that reported by Jackson for this age is 38 grams. Sabotta's figure for the age of puberty, probably taken from the Germans, is 37.5 grams, which is likewise higher than our findings.

In our opinion the points of discrepancy brought out in these findings must in one way or another carry no small significance as to the group we are dealing with now, both from the developmental and nutritional standpoints, even without considering in any further detail the relative state of body weight to stature. Very likely such a condition is closely allied, if not directly con-

nected, with the existence of certain states of nutritional disturbances or of some form of dietary insufficiency in our Filipino children. It has been noticed and reported by our local investigators for some years now, and is generally so admitted that there really exists a general condition of malnutrition among the greater mass of our people. According to Concepcion, the common diet of our people is unbalanced, being deficient in some very important food essentials. That faulty diet, through the lack of proper knowledge of preparing a balanced one, plays an important rôle in the causation of malnutrition in the Philippines. He has determined that the food essentials particularly lacking in the native diet are calcium, vitamin A, and probably vitamins B and C also. He claims that there is a marked preponderance of carbohydrates, relatively little fat, and a relatively low proportion of animal protein in relation to the total protein intake in the ordinary diet of the masses. Tupas, writing on nutrition clinics in schools, found that as high as 40.5 per cent of the school children are underweight, and from his actual observation and figures it appears that malnutrition is most prevalent among children of from 7 to 11 years, inclusive.

Our findings on the thymus as given previously appear to us to substantiate that condition that would really be met with in the body of our children and adolescents if the above-described state of malnutrition and underweight actually exists in the young group of our population. It appeals to us that it may really be possible that under such a condition of undernourishment, and under the disadvantageous influence of deficiency in vitamins, the thymus might have prematurely undergone an early process of involution. Again, that through the particular lack of vitamin B in the ordinary diet of our children and adolescents, the thymus might have really started early its usual process of involution in late childhood. Thus, it is interesting to note that the weight of this organ at this period of life, which coincides with the age of the greatest prevalence of malnutrition as found by Tupas, is proportionately lower than that found for the Americans and the Germans. Through recent studies, it is, of course, known that in cases of vitamin B deficiency the thymus is the first organ to lose weight, and it is also the organ that atrophies the most among the structures of the body that suffer a similar fate.

The possible explanation previously offered on the presence of weight discrepancy of the thymus during late childhood

between Americans and Filipinos—namely, that it might mean the existence of a relatively more rapid progress of body growth at this period of life in Filipinos—is in all probabilities incorrect, because comparative studies on growth, from measurements at this age, show precisely a contrary condition—namely, there are strong indications that body growth in various forms is more rapid with the Americans at this age of life.

On the other hand, our explanation for the presence of a larger thymus in Filipinos at birth, as compared with that of the American newborns, as being due to functional counteraction of the organ against the many unfavorable influences on nurture and environment at that age, does not seem to fit the conditions found in late childhood either, when the thymus is proportionately very much smaller. We believe that under the latter condition—that is, when the child is already born—the nurtural and environmental influences exerted on the body are no longer the same as during intrauterine life, but are much different and changed, to enable the thymus to continue to react or behave in the same manner as before birth. Thus, whereas in the former state the nurtural supply can be considered fairly complete and constant in all the essentials for body growth, the supply after birth is quite variable, particularly in late childhood when the dietary essentials are admittedly deficient and poor. Whereas, again, in the intrauterine life a uniform environment is encountered, that after birth is beset by many unfavorable external influences. Under such conditions, therefore, it is hard to imagine or to explain how the thymus could possibly react functionally in the same favorable way as before birth. On the contrary, all conditions affecting the body will overwhelmingly effect inhibition of its function and probably bring about its subsequent atrophy. In other words, there are many sufficiently unfavorable causes and detrimental factors that will help initiate and hasten the early involution in the thymus, which in fact might have actually taken place during late childhood or early adolescence in our group as indicated by our related findings. We may cite in this connection the findings of Tupas that there exists a considerable percentage of physical defects in our public-school children. His figures are as follows: Dental caries, 76.9 per cent; tonsilitis, 72.6 per cent; pharyngitis, 25.4 per cent; skin diseases, 7 per cent.

He also reports that 97 per cent of the public-school children were found to harbor intestinal parasites of one form or another, and that either trichuris or ascaris eggs or both are found in the

fæcal specimens of these children. Considering, therefore, all these many deterrent factors working together against the body growth of our children in conjunction with the nutritional and vitamin deficiencies admittedly present in the dietary of our people—facts which obviously must inhibit the normal processes of development—we cannot but suspect the close probability of the coexistence of an early involution of the thymus in Filipinos, particularly when this is corroborated by the morphological findings presented in the present work.

Referring now to the comparative standing in the topographic position of the thymus and the frequency of the various types and forms of this organ as found in our series and in the Americans, we have arranged Table 10, representing some of these conditions comparatively at birth and before and after respiration is established, to illustrate more graphically the parallelism existing between the two observations. The data for the Americans were all taken from the work of Nobach.

TABLE 10.—*Comparative condition of the thymus at birth before and after respiration is established in Americans and Filipinos.*

Condition of thymus.	Newborns with respiration not yet established.		Newborns with respiration already established.	
	Nobach.	Nañagas.	Nobach.	Nañagas.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Location:				
Thoracic	----------	----------	20.0	4.2
Thoracocervical	----------	100.0	----------	86.8
Cervicothoracic	80.0	----------	80.0	9.0
Type:				
Unilobar	13.4	----------	----------	----------
Bilobar	57.8	85.7	75.0	36.3
Trilobar	8.8	14.3	15.0	18.1
Conglomerate	20.0	----------	10.0	45.6
Form:				
Broad	82.3	71.4	25.0	36.3
Elongated	17.7	28.6	75.0	63.7
Relation with lungs:				
Both sides overlapped	----------	----------	----------	54.5
Right side overlapped	6.6	----------	100.0	18.1
Left side overlapped	4.4	----------	80.0	----------
No overlapping	----------	100.0	----------	27.4

In the location of the thymus there is a close similarity between the two groups. In a great number of the cases, from 80 to 100 per cent, the organ is found either in the thoracocervical or cervicothoracic positions, and only in a few cases, 20 per cent for the Americans and 4.2 per cent for the Filipinos,

has the exclusive thoracic position of the gland been observed, and in all of these cases the respiration has been already established. In our group of newborns who have already breathed, 86 per cent had the thoracocervical thymus and only 9 per cent had the cervicothoracic location. These findings certainly indicate a strong tendency towards the thoracic position of the thymus among the newborns where respiration had been established. This may probably be explained as the result of the onset of inspiration and the continuance of respiratory movement of the thorax producing the expansion of the costal walls and the contraction or flattening of the domes of the diaphragm, which create thereby a sudden volumetric expansion of the thoracic cavity, and thus determine the pushing in or the traction, if not the suction, downward of the thymus into the anterior mediastinum. This is, in fact the most probable way we can explain the greater prevalence of the thoracic or even the thoracocervical positions of the thymus in the newborns that have had their respiration established. It is at least possible to imagine that the immediate expansion of the thoracic cavity at the onset of the first inspiration could mechanically help the descent of the thymus farther into the mediastinum.

Within the two groups compared not a single case of cervical thymus has been encountered.

As to the number of thymic lobes present in the gland, we have observed that the bilobar type is the most frequent in both the American and Filipino groups.

In the form of the thymus there exists a close coincidence in the two racial groups. The broad form is considerably more frequent in the series that have not breathed, 82.3 per cent for the Americans and 71.4 per cent for the Filipinos. The elongated form, on the other hand, is the commonest in the series that have had respiration established, 75 per cent for the former and 63.7 per cent for the latter. The explanation for this interesting finding has already been presented and discussed in a previous section of this paper (page 292). We are attributing it to the effect of mechanical pressure expansion of the lungs that bound each side of the thymus. With reference to the relation of the thymus to these organs (lungs) it has been observed that there is a partial overlapping of the lungs in one or both sides of the thymus in the majority of the series that have had respiratory function; but conversely in our group, we found not a single case of this overlapping in the newborns that have not yet breathed. This

fact has suggested to us that the presence of this overlapping of organs is to be looked upon as one of the corroborative evidences of established respiration in the autopsies of still-born children showing such condition.

SUMMARY AND TENTATIVE CONCLUSIONS

A total of 338 cases, ranging in age from birth to adolescence, were dissected, examined, and measured for this study. Of these, 202 were males and 136 were females.

The thymus when fresh is soft and easily molds itself in the space occupied. With this natural state of consistency and through the presence of potential available space at the base of the neck, it does not appear to us possible that this organ could effect pressure obstruction or stenosis upon the surrounding structures as clinicians usually claim. On the contrary, its shape and position are invariably affected by the crowding expansion exerted by the lungs and the heart.

The elongated form of thymus is almost invariably found in the newborns that have had respiration established. The reverse, that broad thymus is frequently found in the newborns that have not yet breathed, is also true. These findings are explained by the determining influence of the pressure expansion of the lungs normally encroaching upon the thymus on both sides—the presence of this factor in the former and the absence in the latter.

There is a preponderance of the thoracocervical location of the thymus in Filipino newborns, with a frequency of 86.2 per cent. Few cases show either the cervicothoracic or the exclusive thoracic position of this organ. Not a single case of exclusive cervical position is found in the present series. In older children and in adolescents, on the other hand, the exclusive thoracic position is the one encountered with greater frequency—25 and 65 per cent of all cases, respectively. This shifting of the position of the thymus from the cervical to the thoracic region seems to have been kinetically influenced by the collateral growth processes of the elongation of the neck and the dynamic effect of the expansion of the thorax occurring most rapidly during infanthood and adolescence.

The immediate relations of the thymus vary according to the following factors: The size of the organ itself, the extent of expansion of the two lungs, and the relative inclination and size of the heart. Detailed descriptions of the immediate relations of the organ in Filipinos are given.

In the newborn series the bilobed form of the thymus is found in 48.3 per cent, the conglomerate in 34.5 per cent, and the trilobed in 17.2 per cent of all cases in the series.

The average weight of the thymus exactly at birth in the male is 8.1 grams. The maximum and minimum weights of this organ for the male newborns are 16.2 and 0.9 gram, respectively. The mean weight in the female newborns is 5.5 grams, and the maximum and minimum values are 11.3 and 0.9 gram, respectively. There is thus observed a wide extent of variation in the weight of the thymus in Filipino newborns. This finding is explained by the equally greater degree of variation existing in the general nutrition and body weight of the cases in the newborn series under study.

The weight of the thymus within a few days after birth is found to be consistently greater than at birth. This is true despite the fact that the former group generally possesses less body weight than the latter. The difference in thymic weight is from 30 to 100 per cent, whereas in the body weight it is around 200 grams. These contrasting ponderal differences are attributed to the loss of body fluid normally occurring in the first days of postnatal life and the fact that in all probability the thymus has not been at all affected by it; on the contrary it appears to have shown a rapid rate of growth or enlargement in the first two days of extraüterine life.

In children with a standing height of 100 centimeters, corresponding to about the age of 4.5 years, the weight of the thymus is already double that at birth. At a standing height of 130 centimeters, corresponding approximately to the age of 9.5 years, the weight of the organ is already four times its weight in the newborn.

We have observed that within the time of two distinct age periods of preadolescent life—one between the standing heights of 90 and 100 centimeters, with the approximate age of 4.5 years, and another between 120 and 130 centimeters, within the ages of 9 and 11 years—an abrupt increase in the weight of the thymus is distinctly noticed in each period, particularly so in the latter age interval. We have offered a tentative interpretation of these findings as actual expressions of heightened or accelerated rate of growth of the body at these periods. We attribute the rather rapid enlargement of the thymus to the existence of a collateral increase in its internal secretory function at these two important periods of life. It is, of course, generally known that the absolute weight of the thymus in-

creases quite rapidly up to the third year and is supposed to change but slightly until the seventh year, when the organ starts again increasing in weight and dimensions, which continues to the eleventh year. From this age the thymus rapidly falls in weight and size. We venture to presume that it may be that the precise age periods of rapid exacerbation of increase in size of the thymus, which normally occur in the third and the seventh year of life in the Caucasian children of temperate regions, may really take place correspondingly in the fourth and the ninth year of age in our children of Malayan stock and living in a tropical country. This interesting point naturally requires further study and verification.

It has been shown, further, that the wide extent of variations in the weight of the thymus in our series is directly correlated with the variations in body weight; that emaciated children invariably possess smaller and lighter thymuses, and that heavier ones have this organ larger and heavier also. Our tentative explanation for this is the great probability of the existence, in our emaciated group, of a degree of undernourishment that might be directly associated with a certain premature type of involution of the thymus. It is now known that this gland is the foremost organ to show early involution in cases of malnutrition and starvation, and that under such a condition the thymus sinks proportionately much more in weight than the associated ponderal loss of the whole body. This finding and tentative conclusion require further checking, both experimentally and microscopically, and if confirmed, the needed remedy should be sought for.

Our present data show that at birth Filipino infants possess a proportionately heavier thymus in relation to body weight than those reported by others for the American newborns. The parallel percentage standing of this proportion in the two racial groups is, respectively, 0.54 and 0.42 per cent for the newborns, 0.08 and 0.12 per cent for late childhood, and 0.04 and 0.09 per cent for adolescence. It is also shown in these parallel figures that in late childhood and in adolescence the Filipinos, however, have a proportionately smaller thymus than does the American group. The presence of a larger thymus in the Filipino newborns we consider due to the existence of a certain functional reaction (counteraction) of the organ against several unfavorable influences of nurture during the fœtal age in the maternal womb when the intrauterine environment is more favorable to the proper development of the body

than are the external environmental conditions after birth. The discrepancy in proportional weights seen in late childhood, on the other hand, is in our opinion closely allied, or directly dependent upon the existence of nutritional imbalance or dietary insufficiency in our children. This condition of insufficiency is now generally recognized to exist in the greater mass of our population. Really, if with the degree of undernourishment and the extent of deficiency in vitamines A and B claimed by local investigators to exist in the majority of our children, we add the aggravating condition of high incidence of intestinal parasitism in our children (97 per cent), it is not hard to imagine the seriousness of this nutritional condition which may in fact affect the thymus by hastening its premature involution in many of our children. Under such a condition, it can be imagined how much this early thymic involution can lessen the general efficiency, the vigor, the resistance to disease, and the intelligence of the young population of the race. This important problem, with its many collateral issues intimately connected with the general improvement of the race and the welfare of the people, is hardly touched upon and much less solved or remedied. This and similar questions are of the greatest importance to study and to remedy, if the race is to advance and overcome the existing handicaps to keep pace with other and more-advanced peoples. Our institutions and our Government can hardly afford to neglect or disregard such national problems urgently demanding solution.

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ILLUSTRATIONS

PLATE 1

Topographic tracing stage and tracing ocular.

TEXT FIGURES

FIG. 1. Relations and topography of the thymus in a fœtus that has not yet breathed (case 24); *a*, anterior relations; *b*, posterior relations.

2. Relations and topography of the thymus in a newborn that has had respiration established (case 22); *a*, anterior relations; *b*, posterior relations.

3. Two typical forms of elongated thymus as produced by the pressure expansion of the lungs; *a*, case 7; *b*, case 18.

4. Different forms and shapes of the thymus.
   a, Unilobar type, case 20.
   b, Bilobar type, case 9.
   c, Trilobar type, case 16.
   d, Conglomerate type, case 23.

5. Ponderal rate of growth of the body and the thymus from the time of birth to the fifteenth year of age.

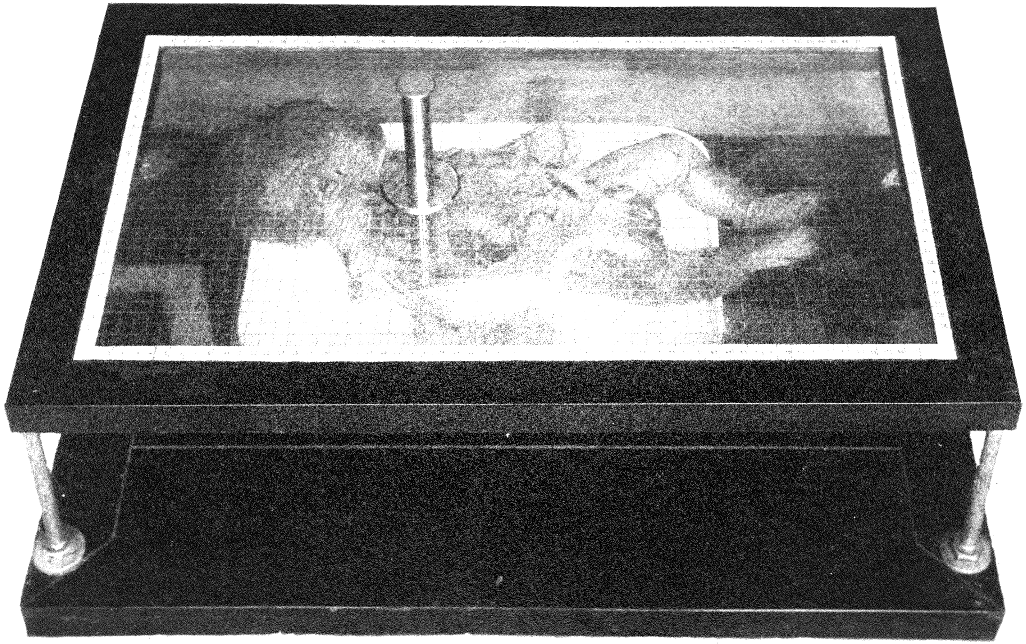

PLATE 1.

PHYSIOLOGY OF REPRODUCTION IN THE RABBIT

AGE OF SEXUAL MATURITY, BREEDING SEASON, DURATION OF NORMAL PREGNANCY, AND OVULATION [1]

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INTRODUCTION

In the spring of 1924 Warwick and Gildow started an experiment to determine whether or not there is a genetic basis for the difference in susceptibility of rabbits to a particular strain of *Brucella abortus* organism, *Alkaligenes abortus* (Bang) Berge et al. The writer took up the work a year later and continued it for three years longer, thus making a total of four years' study on the experiment. During that time some data bearing on certain phases of the physiology of reproduction, such as the age at sexual maturity, the trend of litter production in different seasons, the duration of normal pregnancy, the size of the litter, and the occurrence of ovulation, were accumulated, and it seems best to publish them as a separate paper. The literature on this subject is still very limited, and although a number of investigators in Europe have reported the results of their work, our knowledge of the phenomena of reproduction in the rabbit is far from being complete.

[1] Materials used in this paper were a portion of the dissertation presented to the faculty of the Graduate School, University of Wisconsin, Madison, Wisconsin, in partial fulfillment of the requirements for the degree of Doctor of Philosophy. Another portion of the paper was published in the Journal of Infectious Diseases 51 (July-August, 1932) 30–71, under the title, Studies on the Inheritance of Resistance and Susceptibility to Infectious Abortion. These studies were begun by B. L. Warwick and E. M. Gildow in 1924 under the joint direction of Dr. L. J. Cole, professor of genetics, and Dr. F. B. Hadley, professor of veterinary science, University of Wisconsin. The writer took up the work a year later and continued it till June, 1928.

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THE AGE OF SEXUAL MATURITY

In the journal containing breeding records of the stock of rabbits we find some data on a fairly large number of does which could be used to determine the earliest time when coitus occurs and the age at their first fertile mating. The does were placed in separate cages when about four months old. They were visited at regular hours daily and placed with the males for about five to ten minutes or until coitus had taken place. In no case was the female left in the same cage with the buck overnight. Coitus before four months was observed, by chance, on animals kept in common pens. These observations were occasional and were recorded while going our rounds. It is obvious that many other cases of coitus might have occurred at other times. These data are shown in Table 1.

TABLE 1.—*Showing the age at which female rabbits become sexually mature.*

Group A.		Group B.	
Age at first coitus.	Number of does.	Age at first fertile coitus.	Number of does.
Days.		*Days.*	
83	1	113	2
98	2	128	7
113	3	143	5
128	8	158	5
143	9	173	15
158	13	188	11
173	13	203	13
188	13	218	16
203	10	233	15
218	17	248	8
233	13	263	4
248	4	278	7
263	5	289	8
278	4	308	10
289	8	Total	126
308	3	Mean age—7.5 months.	
Total	126		
Mean age—6.5 months.			

It may be seen in Table 1 that the time of first coitus occurred between 83 and 308 days, with the mean at about 6.5 months. The first fertile mating took place between 113 and 308 days, with the mean at about 7.5 months. Under conditions that

prevail in Cambridge, England, Hammond (1925) found that young does frequently allow coitus one or two months before the first ovulation takes place. Our data indicate that a similar situation may hold true for does in Wisconsin. They also suggest that the best time to begin breeding the does is when they are about seven to eight months old.

BREEDING SEASON

It is commonly believed that under suitable conditions rabbits will breed at all times of the year. For example, rabbits kept in tropical countries may be seen to drop their young throughout the year. In temperate countries, however, this is not the case. Hammond (1925) states that in England rabbits will copulate more readily in the spring and summer months, from April to July, than they will in the autumn and winter, from September to March. Under Wisconsin conditions it appears that the period from March to July is the most favorable season for rabbits to breed. The least favorable is in summer from July to September, but rabbits will breed from September to March as may be seen in Table 2.

TABLE 2.—*Showing the frequency of litters of rabbits born in two different colonies between March, 1924, and June, 1928, and the percentages of all litters in different seasons of the year.*[a]

Colony.	Autumn.		Winter.		Spring.		Summer.		Total.	
	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.	Cases.	Per cent.
I (Genetics Barn)	75	33.33	47	20.89	79	31.11	24	10.67	225	100.00
II (Serum Plant)	45	24.86	50	27.62	56	30.95	30	16.27	181	100.00
Total	120	58.19	97	48.51	135	66.06	54	27.24	406	----------
Average	--------	29.095	--------	24.255	--------	33.03	--------	13.62	--------	100.00

[a] Litters born from September 23 to December 21 are included under autumn; from December 22 to March 20, under winter; from March 21 to June 20, under spring; and from June 21 to September 22, under summer.

It may be seen in the table that animals kept in the same locality but in different buildings may show slight differences in litter production. For example, the rabbits in the Genetics Barn produced a few more litters in autumn and spring while those in the Serum Plant produced more in the winter and summer. These differences were presumably due to environmental inequalities such as the construction of the buildings, ventilation, means of heating, feeding, etc.

DURATION OF NORMAL PREGNANCY

Data on the duration of normal pregnancy have been secured from a total of 283 uninoculated stock females. These rabbits were kept in separate cages and visited regularly at a definite time every day. Aborted young were not included, thus making these data of direct practical value.

TABLE 3.—*Showing the duration of normal gestation period in the rabbit.*

From copulation to birth of litter, days.	Frequency.	Percentage.	
28	1	[a] 0.35	
29	2	[a] 0.71	
30	35	12.37	95.4
31	134	47.35	
32	76	26.88	
33	25	8.83	
34	8	2.83	
35	2	0.71	
Total	283	100.00	

Mean	31.43 days.
P. E_m	±0.06199 day.
σ	1.56 days.
C. of V	4.96 per cent.

[a] Weak undersized young which died soon after birth.

It may be noted from Table 3 that the duration of normal pregnancy varied from 28 to 35 days from the time of copulation to birth of litter, with the mean at 31.43 $\pm$ 0.062 days. Ninety-five (95.4) per cent of the 283 cases of pregnancy studied lie between 30 and 33 days, the mode being at 31 days. Nearly 50 per cent of the litters were born 31 days after insemination. These data are in agreement with those of Hammond (1925), who reported that the gestation period in 296 rabbits which he studied varied from 30 to 34 days with the mean at slightly under 32 days.

CORRELATION BETWEEN THE SIZE OF LITTER AND THE LENGTH OF GESTATION PERIOD

It is a well-known fact that, in general, in those species which bear one or two young at birth the length of the gestation period is relatively longer than in those which have several young to each litter. As there is in rabbits considerable variation in the size of litter it would seem that there might be a similar reciprocal relation to duration of pregnancy.

From the records of 220 individuals studied we find a negative correlation between the size of litter and the length of gestation period with a coefficient of —0.26 ± 0.042 as may be seen in Table 4.

The values of X and Y are:

Size of litter, X: Mean = 6.18; $\sigma = 1.71$.

Length of gestation period, Y: Mean = 31.49; $\sigma = 1.02$.

$$r = -0.2645 \pm 0.0422$$

TABLE 4.—*Showing correlation between the size of litter and the length of gestation period in days.*

Length of gestation period, Y.	Size of litter, X.												
	1	2	3	4	5	6	7	8	9	10	11	12	
Days.													
28	-----	-----	-----	-----	-----	-----	1	-----	-----	-----	-----	-----	1
29	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0
30	-----	-----	-----	3	3	5	6	5	2	-----	-----	-----	24
31	-----	2	2	2	20	25	29	13	7	3	-----	-----	103
32	-----	-----	3	7	15	17	6	12	-----	-----	-----	1	61
33	-----	-----	5	2	5	1	4	3	-----	1	-----	-----	21
34	1	-----	-----	1	2	-----	3	1	-----	-----	-----	-----	8
35	1	-----	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	2
Total	2	2	11	15	45	48	49	34	9	4	-----	1	220

It is seen in Table 4 that the correlation coefficient is slightly over six times its probable error. While the correlation is small, indications are that there is a reciprocal negative relation between the size of the litter and the length of the gestation period in the rabbit; namely, the smaller litters tend to be carried longer than the larger ones. Other factors are probably concerned; such as, inherited characteristics of certain does for prolonged or shortened gestation periods; age of the animals, it being known that in sows, for example, the gilts have relatively shorter gestation periods than old sows; size of individuals in the litter, nutrition; and seasonal variations.

OVULATION AFTER PARTURITION

Our interest in the question of ovulation after parturition lies in the consideration of the fact that if spontaneous ovulation without coitus does take place in the rabbit after parturition, a relatively larger number of females could be artificially inseminated at one time with spermatozoa from a single male. Those who have worked on this subject are at variance as to whether or not ovulation occurs after parturition without the necessary stimulus incident to coitus. Weil (1873) cited Bischoff to the effect that copulation has nothing whatever to do with ovulation other than to hasten the process, and Ivanoff (1900) claims to have induced fertility by artificial insemination without coition after parturition. Hammond (1925), on the other hand, has presented indirect evidence to show that spontaneous rupture of the Graafian follicles does not occur without coitus. He mated does at varying intervals after parturition to bucks of known fertility. Of the twenty-five does so mated from the first to the thirty-sixth day after parturition, twenty allowed coitus and nineteen became pregnant. This was taken as conclusive evidence to show spontaneous ovulation had not occurred, for otherwise these matings would have been infertile owing to the formation of corpora lutea of pseudopregnancy.

Evidence directly confirming the data of Hammond have accumulated in the course of our work, from observation on the does which were subjected to post-mortem examination for other purposes after parturition. In some of these does the presence or absence of newly ruptured follicles was incidentally recorded. The results are given in Table 5.

All the sixteen does listed in Table 5 were kept in separate cages and had had no direct contact with the males or any other females from the time they littered to the day when examinations were made. There had been no possibility of occasional ovulation which according to Hammond (1930) may be stimulated by the excitement produced by two females jumping on one another. Seven of the sixteen produced normal litters; the remaining aborted their young. It may be seen that none of the sixteen showed newly ruptured follicles. Newly ruptured follicles are easily recognized as bright red protrusions on the surface of the ovary and can thus be easily differentiated from the mature follicles, which are rounded protruding bodies filled with clear pink or amber fluid.

TABLE 5.—*Showing the number of ripe follicles found at post-mortem examination of **does that had not been mated** to males after parturition.*

[Ab, aborted litter; Nr, normal litter.]

Doe No.—	Nature of parturition.	Post-mortem examination made after parturition (days).														Recently ruptured follicles.		Ripe follicles.	
		1.25	1.5	1.75	2	3	4	5	6	10	15	20	25	30	35	Right.	Left.	Right.	Left.
175A1	Ab	×	----	----	----	----	----	----	----	----	----	----	----	----	----	0	0	3	3
47D3	Nr	----	×	----	----	----	----	----	----	----	----	----	----	----	----	0	0	5	6
185A23	Nr	----	×	----	----	----	----	----	----	----	----	----	----	----	----	0	0	3	3
17D2	Ab	----	----	×	----	----	----	----	----	----	----	----	----	----	----	0	0	8	4
194A2	Nr	----	----	----	×	----	----	----	----	----	----	----	----	----	----	0	0	5	4
215A2	Ab	----	----	----	×	----	----	----	----	----	----	----	----	----	----	0	0	5	4
48D2	Ab	----	----	----	----	×	----	----	----	----	----	----	----	----	----	0	0	7	5
60A1	Ab	----	----	----	----	----	×	----	----	----	----	----	----	----	----	0	0	4	3
171A13	Ab	----	----	----	----	----	----	×	----	----	----	----	----	----	----	0	0	4	7
38A2	Nr	----	----	----	----	----	----	----	×	----	----	----	----	----	----	0	0	5	7
215A3	Nr	----	----	----	----	----	----	----	×	----	----	----	----	----	----	0	0	6	7
10D2	Ab	----	----	----	----	----	----	----	----	----	×	----	----	----	----	0	0	(a)	(a)
180A4	Nr	----	----	----	----	----	----	----	----	----	----	×	----	----	----	0	0	0	0
11D8	Nr	----	----	----	----	----	----	----	----	----	----	----	----	×	----	0	0	3	4
173A3	Ab	----	----	----	----	----	----	----	----	----	----	----	----	----	×	0	0	(a)	(a)
207A1	Ab	----	----	----	----	----	----	----	----	----	----	----	----	----	×	0	0	0	0

[a] Follicles filled with clear colorless fluid.

SUMMARY

The following summary may be drawn from the foregoing discussion.

1. The age at which female rabbits become sexually mature is from 113 to 303 days, the average being seven and a half months, but they may accept the males about a month earlier.
2. The duration of normal pregnancy is from 30 to 33 days.
3. When placed under suitable environment they continue to produce litters throughout the entire year, but in Wisconsin the highest litter production is secured in the spring and the lowest in summer months.
4. A small but significant negative correlation ($r = -0.26 \pm 0.042$) between the size of litter and the duration of pregnancy was found, indicating the existence of a reciprocal relationship.
5. Spontaneous ovulation after parturition does not occur in the rabbit. The stimulus of coitus appears to be necessary for its occurrence.

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DIE PHILIPPINISCHEN ARTEN DER UNTERGATTUNG CALLIRRHIPIS (COLEOPTERA)

ZUR KENNTNIS DER SANDALIDÆ 19; ZUGLEICH PHILIPPINISCHE SANDALIDÆ 2

Von FRITZ VAN EMDEN

Dresden (Nr. 58), Deutschland

Dieser zweiter Teil der Bearbeitung der philippinischen Sandalidæ umfasst die Untergattung *Callirrhipis* s. str.[1] Es sind die grossäugigen Callirrhipini ohne zehn regelmässige Punktstreifen, mit im männlichen Geschlecht langen Fühlerlamellen und kurzen Fühlergliedern sowie spärlicher bis wenig dichter Hauptpunktierung der Flügeldecken oder seltener dichter Hauptpunktierung, dann aber mit nur schwach entwickelten Rippen. Bekannt waren bisher von den Philippinen—abgesehen von den inzwischen aus *Callirrhipis* ausgeschiedenen *Simianellus*-Arten— fünf Arten dieser Untergattung, von denen alerdings *viracensis* W. Schultze (1918) mit *antiqua* Waterhouse (1877) artgleich ist, während dafür *antiqua* W. Schultze (1915, nec Waterhouse) neu benannt werden muss. Hierzu kommt die von Waterhouse (1877) aus Borneo beschriebene, inzwischen von Prof. Baker auch auf Palawan (Puerto Princesa) gefundene *C. lineata* und neun neue Arten und Rassen, sodass die Zahl der philippinischen *Callirrhipis* s. str. mit vorliegender Arbeit auf fünfzehn erhöht wird.

Dank schulde ich Herrn W. Schultze, Bad Tölz, für das Leihen seiner Typen, dem verstorbenen Prof. C. F. Baker, Los Baños, beziehungsweise dem United States National Museum, Baker Collection, für das Leihen seines Materiales, sowie Herrn Prof. Dr. H. Wachs, Herrn Dr. A. Kästner und dem verstorbenen Herrn Rektor G. Schröder, sämtlich in Stettin, für das Leihen der Sandalidæ des Stettiner Naturkundemuseums.

Nomenklatorische Ergebnisse: *C. viracensis* W. Schultze (1918) wird synonym zu *antiqua* Waterhouse (1877); neu beschrieben werden *sandaloides* (= *antiqua* Schultze, 1915, nec

[1] Siehe Ent. Blätt. 27 (1931) 51.

Waterhouse), *luzonica* und *rugicollis* von Luzon, *acutipennis* von Mindanao, *longitarsis* und *schultzei* von Panay, *grisea* von Mindoro, *bakeri* von Samar, *parallela* von Negros und *helleri meridionalis* von Mindanao und Samar.

Bestimmungstabelle der Arten der Untergattung Callirrhipis.

1 (20) Behaarung der Flügeldecken beim Männchen verschieden gelagert, die Decken dadurch fast immer gescheckt erscheinend. Der vor dem Fühlerhöcker gelegene Teil der Stirn auch in der Mitte stets stark von ihm abgesetzt, in der Horizontalebene des Kopfes plattenförmig vorgezogen und die Oberlippe samt Clypeus überdeckend, der Vorderrand höchstens in der Mitte leicht ausgerandet. Ovipositor des Weibchens ohne stumpfe Seitenecke. Die Flügeldeckenrippen verhältnismassig kräftig, die 1. mündet nach aussen biegend in die 2., diese vereinigt sich, ebenfalls etwas nach aussen biegend, mit der 4., nachdem letztere kurz vorher die flache 3. Rippe aufgenommen hat. Die Flügeldecken vor der Vereinigung der 1. und 2. und noch mehr vor der der 2. und 4. konkav gewölbt .... *C. dissimilis*-Gruppe.

3 (3) Flügeldecken des Männchens nicht gescheckt. Körper, besonders beim Weibchen sehr robust (3–3, zweimal so lang wie an den Schultern breit) und das Weibchen im Habitus an *Sandalus* erinnernd. LUZON, Benguet, Baguio; Nueva Viscaya, Imugan. *C. sandaloides* sp. nov.

3 (2) Flügeldecken des Männchens gescheckt. Körper schlanker, beim Weibchen 3.4 mal so lang wie an den Schultern breit oder länger.

4 (7) Halsschildseitenrand mit sehr starkem, breitem Seitenrandeindruck, sodass die Kontur breit und tief ausgerandet erscheint. Fühler fast oder reichlich von Körperlänge.

5 (6) Flügeldecken am Ende am Aussenrande gerade zugespitzt. Erstes Tarsenglied etwas länger als die beiden folgenden zusammen, Halsschild hinter dem Vorderrand etwas breiter als an den Seitenrandeindrücken. MINDANAO................ *C. acutipennis* sp. nov.

6 (5) Flügeldecken am Ende des Aussenrandes deutlich flach gerundet. Halsschild an den Seitenrandeindrücken breiter als hinter dem Vorderrand; also von der Spitze bis zur Basis dauernd wenn auch ungleichmässig an Breite zunehmend. LUZON. *C. lagunæ* Schultze (1916).

7 (4) Halsschildseitenrand mit meist deutlichem, doch wenig grossem Seitenrandeindruck, die Kontur also höchstens flach ausgerandet erscheinend.

8 (11) Fühler des Männchens lang (drei Viertel körperlang bis körperlang), Tarsen schlanker.

9 (10) Halsschild nach vorn stark verengt, zwischen den Vorderecken der Kontur halb so breit wie an der Basis, mit tiefen, grossen Discoidaleindrücken. Marmorierung der Flügeldecken beim Männchen sehr auffällig, Rippen sehr kräftig. Schildchen hinten breit abgerundet-abgestutzt. PANAY .... *C. schultzei* sp. nov.

10 (9) Halsschild nach vorn mässig stark verengt, zwischen den Vorderecken der Kontur zwei Dritteln so breit wie an der Basis, mit wenig tiefen, kleinen Discoidaleindrücken. Marmorierung der Flügeldecken wenig auffällig, Rippen mässig kräftig. PANAY.
C. longitarsis sp. nov.

11 (8) Fühler des Männchens bis reichlich zwei Dritteln so lang wie der Körper. Tarsen normal, das 1. Glied kürzer als 2. + 3., 2. bis 4. höher als lang, Klauenglied deutlich erweitert.

12 (13) Schildchen breiter als lang, hinter der Mitte am breitesten, der Hinterrand breit abgerundet. Körper schwarzgrau gefärbt. Scheckung unauffällig. Die Zwischenräume der Halsschildpunktierung nirgends stärker erhaben, daher nicht stellenweise runzlig oder ölig erscheinend. MINDORO........ *C. grisea* sp. nov.

13 (12) Schildchen länger als breit oder breiter als lang, dann aber deutlich vor der Mitte am breitesten und hinten abgerundet-zugespitzt. Körper braun gefärbt. Scheckung auffälliger. Die Zwischenräume der Halsschildpunktierung stellenweise stärker erhaben und runzlig oder ölig-zusammengeflossen erscheinend.

14 (15) Fühler reichlich zwei Dritteln so lang wie der Körper. Jederseits vor und ausserhalb der Discoidaleindrücke noch ein kleiner, rundlicher, ziemlich tiefer, dem Discoidaleindruck ähnlicher, Eindruck. Obwohl dieser beiderseits vorhanden ist, handelt es sich möglicherweise um eine Monstrosität. Präscutellareindrücke sehr gross und kaum weniger tief als die Discoidaleindrücke. Flügeldecken der Länge nach ziemlich stark gewölbt mit ausserordentlich stark erhabenen, breiten Rippen. SAMAR.
C. bakeri sp. nov.

15 (14) Fühler bis zwei Dritteln so lang wie der Körper. Halsschild jederseits mit nur einem Discoidaleindruck. Präscutellareindrücke kaum grösser, wenn auch weniger deutlich begrenzt, und viel flacher als die Discoidaleindrücke. Flügeldecken der Länge nach schwach gewölbt mit mässig entwickelten Rippen.

16 (17) Die 1. und 2. Rippe in der Basalhälfte der Flügeldecken äusserst schwach erhaben, die Zwischenräume zwischen den Rippen demgemäss in der Basalhälfte unmerklich, in der Apikalhälfte schwach konkav. Flügeldecken sehr schlank und auffällig parallel. Hauptpunktierung der Flügeldecken ziemlich fein und wenig dicht. NEGROS .... *C. parallela* sp. nov.

17 (16) Die 1. und 2. Rippe in der Basalhälfte der Flügeldecken deutlich erhaben, die Zwischenräume zwischen den Rippen deutlicher konkav, Zum Teil auch in der Basalhälfte. Flügeldecken weniger schlank und weniger parallel, Hauptpunktierung viel gröber und dichter.

18 (19) Die Zwischenräume der Halsschildpunktierung nur jederseits ausserhalb der Hinterecken etwas runzlig verliessend, vorn auf der Scheibe nur wenig merklicher erhaben als bei *grisea*. Die Rippen der Flügeldecken breit und stark erhaben und allmählich in die konkaven Zwischenräume übergehend, jederseits durch eine wenig regelmässige Punktreihe begrenzt. Hauptpunktierung

wenig grob und mässig dicht. Flügeldecken wenig stark zugespitzt. Färbung dunkel rotbraun. LUZON, Tayabas, Malinao.
C. luzonica sp. nov.

19 (18) Die Zwischenräume der Halsschildpunktierung überall stark ölig-zusammenfliessend. Die Rippen der Flügeldecken wenig breit und wenig stark erhaben, doch jederseits durch eine ziemlich regelmässige Punktreihe sehr scharf von den schwach konkaven Zwischenräumen abgesetzt, Hauptpunktierung grob und dicht. Flügeldecken stärker zugespitzt. Färbung heller rotbraun, Scheckung feiner. LUZON .... *C. rugicollis* sp. nov.

20 (1) Behaarung der Flügeldecken beim Männchen fast einheitlich nach hinten gerichtet oder mehr oder weniger geschwunden. Der vor dem Fühlerhöcker gelegene Teil der Stirn fällt beim Weibchen—soweit bekannt—stets, beim Männchen meistens in der Mittellinie kurz und schräg zum Vorderrand ab, nur die Vorderecken springen stärker vor, sodass der Vorderrand breit bogenförmig ausgeschnitten erscheint und Oberlippe und Clypeus im Ausschnitt sichtbar werden.

21 (26) Körper rotbraun bis pechbraun. Die Rippen der Flügeldecken beim Männchen auch an der Basis nicht auffällig dichter behaart als die Zwischenräume, Rippen und Zwischenräume beim Männchen nie kahl. Ovipositor des Weibchens mit stumpfer Seitenecke. Mittlere Arten.

22 (25) Punktierung des Halsschildes und Hauptpunktierung der Flügeldecken fein. Der vor dem Fühlerhöcker gelegene Teil der Stirn beim Männchen plattenförmig vorgezogen (beim Weibchen kurz abfallend und bogenförmig ausgeschnitten). Die Präscutellareindrücke flach und undeutlich, Discoidaleindrücke auch hinten aussen gut begrenzt. Halsschild ziemlich lang, vorn breiter und die Seiten ziemlich geradlinig. Fühler des Männchens mittellang bis lang.

23 (24) Die Rippen fast völlig verflacht, besonders auch hinter der Vereinigung der 1. und 2., die sie begleitenden Punkte nicht dichter und gröber als die der Zwischenräume. Körper etwas schlanker. LUZON .... *C. helleri* Schultze (1915).

24 (23) Die Rippen etwas erhaben, besonders hinter der Vereinigung der 1. und 2., die sie begleitenden Punkte etwas dichter und gröber als die der Zwischenräume. MINDANAO. SAMAR.
C. helleri meridionalis subsp. nov.

25 (22) Punktierung des Halsschildes und Hauptpunktierung der Flügeldecken grob. Der vor dem Fühlerhöcker gelegene Teil der Stirn in beiden Geschlechtern kurz abfallend und bogenförmig ausgeschnitten. Die Präscutellareindrücke ziemlich tief und sehr deutlich, Discoidaleindrücke hinten aussen mit den Hintereckeneindrücken verfliessend. Halsschild kurz, kreisbogenförmig, nach vorn mehr gerundet und stärker verengt. Fühler des Männchens wenig lang. LUZON bis MINDANAO.
C. antiqua Waterhouse (1877).

26 (21) Körper rostrot bis bräunlichrot. Die Rippen der Flügeldecken beim Männchen wenigstens an der Basis dichter behaart als die Zwischenräume. Bei den philippinischen Arten fällt der vor dem Fühlerhöcker befindliche Teil der Stirn kurz und steil ab und ist vorn breit und tief ausgerandet. Kleine Arten.

27 (28) Behaarung und Grundpunktierung der Flügeldecken beim Männchen auch in den Zwischenräumen der Rippen stark entwickelt, nur der Schildchenstreif und manchmal die Basis der 1. Rippe dichter behaart. Halsschild dicht punktiert, sodass die meisten Punkte um weniger als ihren Durchmesser voneinander entfernt sind, der Länge nach nur sehr flach gewölbt, die Vorderecken sehr breit abgerundent und nur schwache Augenlappen bildend. Weibchen unbekannt. Männchen 9.5 bis 11.3 mm. LUZON. MINDANAO. SALAWATI. BATJAN.

C. tiaongona Schultze (1915).

28 (27) Behaarung und Grundpunktierung der Flügeldecken beim Männchen fast ausschliesslich auf den Rippen entwickelt, auch die Naht und öfters mehr oder weniger die äusseren Rippen behaart. Halsschild wenig dicht punktiert, sodass die meisten Punkte um mehr als ihren Durchmesser voneinander entfernt sind, der Länge nach ziemlich flach gewölbt, die Vorderecken mässig breit abgerundet und kräftige Augenlappen bildend. Weibchen bis auf die Behaarung und Grundpunktierung der Flügeldecken wie das Männchen. Halsschild mit unregelmässiger, grösstenteils etwas feinerer, wenig dichter Punktierung. Männchen 9.5 bis 11.5, Weibchen 16.5 mm. PALAWAN. BORNEO. SUMATRA.

C. lineata Waterhouse (1877).

CALLIRRHIPIS SANDALOIDES sp. nov.

Fünf Männchen, 4 Weibchen, LUZON, Benguet, Baguio (Männchen und Weibchen, *Baker*, United States National Museum); 2 Männchen, 2 Weibchen (*Böttcher*, Mus. Dresden); Männchen und Weibchen ebenda 1,600 m. (Samml. W. Schultze, davon das Männchen jetzt in Mus. Dresden); Männchen (Samml. W. Schultze); 1 Männchen N. W. LUZON (Mus. Stettin); 1 Männchen LUZON, Nueva Vizcaya, Imugan, *Baker* (Mus. Dresden), insgesamt liegen also 7 Männchen und 4 Weibchen vor. Ferner besitzt des Städtische Museum für Natur-, Völker- und Handelskunde, Bremen, 3 Männchen, davon 2 von Santo Tomas, 1 von Haight's, alle von O. Schütze gesammelt. Beide Orte liegen in Benguet.

Männchen.—Körper dunkel kastanienbraun; Fühler, Beine und Flügeldecken kastanienbraun. Behaarung sehr fein, ziemlich lang und ganz anliegend, wechselnd gelagert, vor allem von den Zwischenräumen nach den Rippen und etwas nach hinten gerichtet, sodass die auf den Rippen von beiden Seiten zusam-

menstossenden Haare und die auf ihnen stehenden die Rippen besonders betonen und die Haare grossenteils zueinander in Form eines breiten V angeordnet sind. Kopf ziemlich fein und sehr dicht punktiert. Drittes Glied der Kiefertaster ein Sechstel kürzer als das 2. Anderthalbmal so lang wie breit, das 4. ein und ein Drittel so lang, knapp zweimal so lang wie breit, zur Spitze stark zugerundet. Fühler halb bis drei Fünfteln (0.52 + 0.57 mal) so lang wie der Körper, schon das 3. Glied deutlich länger als breit. Halsschild mässig kurz, zur Spitze stark verengt und kräftig gerundet, die Seiten konvex gerundet, der Seitenrandeindruck fast stets sehr seicht, die Kontur durch ihn fast nie ausgerandet; unmittelbar von den Hinterecken sind die Seiten äusserst kurz aber meist sehr deutlich etwas ausgerandet. Die herabgeschlagenen Vorderecken etwas gerundet vorgezogen, selbst bei monokularer Betrachtung von oben beiderseits etwas sichtbar. Halsschildpunktierung fein und mässig dicht, zur Basis sehr fein werdend, die Zwischenräume nicht ölig verfliessend. Discoidaleindrücke ziemlich tief, ringsum scharf gegrenzt, Präscutellareindruck einfach, fast völlig erloschen, Hintereckeneindrücke ausserordentlich flach. Halsschild sehr flach und sehr gleichmässig gewölbt. Schultern ziemlich viel breiter als die Halsschildbasis, stark gerundet. Flügeldecken von den Schultern an kaum merklich verengt, vom Anfang des letzten Drittels an stärker gerundet-verengt, etwas abgerundet-zugespitzt. Rippen breit und stark erhaben, doch die eigentliche Rippen völlig unscharf in die Zwischenräume übergehend, die 3. Rippen deutlicher als bei anderen Arten, die gemeinsame Verlängerung der Rippen ist wenig deutlich und erreicht mehr oder weniger erkennbar Naht oder Seitenrand kurz vor der Spitze. Hauptpunktierung äusserst fein und spärlich, zwischen der verhältnismässig sehr groben, wenig dichten Grundpunktierung wenig auffallend. Die Flügeldecken kaum stellenweise mit angedeuteter Knitterung. Flügeldecken in den basalen zwei Fünfteln ziemlich kräftig gewölbt, im übrigen fast eben und nur zur Spitze selbst wieder etwas gewölbt abfallend, der Breite nach ziemlich kräftig gewölbt. Schienen und Tarsen mässig schlank, das 2. und 3. Glied der Vorder- und Mitteltarsen nur wenig höher als lang. Länge 13.3 bis 15.8 mm. Schulterbreite 4.1 bis 5.0, Fühlerlänge 7.0–9.0.
mm, Schulterbreite 4.1 bis 5, Fühlerlänge 7 bis 9.

Weibchen.—Pechbraun bis pechschwarz. Durch die stark entwickelten Flügeldeckenrippen, den (wie beim Männchen)

plattenförmig vorgezogenen Vorderteil der Stirn und das Fehlen einer stumpfen Seitenecke des Ovipositors mit den anderen Weibchen der *dissimilis*-Gruppe übereinstimmend, jedoch von allen bekannten *Callirrhipis* Weibchen durch die viel kürzere und robustere, an *Sandalus* erinnernde Gestalt, auffällig verschieden. Kopf wenig dicht und mässig fein punktiert. Fühler sehr kurz, von etwa ein Fünftel der Körperlänge, das 4. bis 10. Glied breiter als lang, das 11. eiförmig bis länglich eiförmig, die Lamellen des 3. bis 10. an Länge wenig verschieden, weniger als dreimal so lang, das 3. nur ebenso lang wie das zugehörige Glied. Halsschild vorn sehr breit gerundet, dem des Männchens ähnlich, doch etwas gewölbter und zwischen der ziemlich feinen und wenig dichten Grundpunktierung nach den Seiten und der Spitze zu mit eingestreuten gröberen Punkten, die Punktierung auf der Scheibe mehr oder weniger erlöschend. Präscutellareindruck erloschen oder fast erloschen. Discoidaleindrücke klein und wenig tief, doch scharf begrenzt. Schildchen nur mit einigen feinen, zerstreuten Punkten. Flügeldecken bis zum Ende des zweiten Drittels ziemlich stark erweitert, dann kräftig gerundet-verengt, an der Spitze breit abgerundet. Rippen sehr breit und stark erhaben, sie verlaufen wie in dieser Gruppe allgemein, die gemeinsame Verlängerung zieht wenig erhaben, doch deutlich bald zum Aussenrand, bald zum Seitenrand. Grundpunktierung ziemlich grob; sehr zerstreut und in der Basalhälfte fast völlig erloschen, die Rippen infolgedessen ziemlich stark glänzend, ebenso der Halsschild. Die Zwischenräume erscheinen dem unbewaffneten Auge demgegenüber infolge der ziemlich feinen und wenig dichten Hauptpunktierung ziemlich matt. Schienen und Tarsen wenig schlank, das 2. bis 4. Glied der Tarsen viel höher als lang. Länge 16.8 bis 20.2 mm, Schulterbreite 5.5 bis 6.7.

Durch die kurze Körperform, besonders des Weibchens, und die nicht gescheckte sondern breit V-förmig gelagerte Flügeldeckenbehaarung des Männchens ist diese mit den Merkmalen der *dissimilis*-Gruppe ausgestattete Art von allen anderen *Callirrhipis*-Arten leicht zu unterscheiden und ausserordentlich auffällig. Auf diese Art beziehen sich W. Schultzes Angaben, Philip. Journ. Sci. § D 10 (1915) 273, über *C. antiqua* wie die Bemerkungen über Flügeldeckenrippen und Flügeldeckenbehaarung deutlich erkennen lassen. Zu *C. sandaloides* ist also synonym *C. antiqua* Schultze (1915, nec Waterhouse, 1877).

CALLIRRHIPIS ACUTIPENNIS sp. nov.

Männchen.—MINDANAO, Zamboanga (Ort Zamboanga), Samml. W. Schultze. Dunkel kastanienbraun, die Flügeldeckennaht in den letzten zwei Dritteln, Bauch, Schienen und Tarsen etwas heller rotbraun; die Fühler hell rotbraun, graugelb bis goldgelb fein anliegend behaart. Das Schildchen, ein etwa halbkreisförmiger hinter der Schulter beginnender, nach innen bis an die erste Rippe, nach hinten bis fast ans Ende des dritten Fünftels reichender Fleck am Seitenrand sowie je ein kleinerer, mit dem Seitenrand unregelmässig zusammenhängender Fleck zwischen der zweiten und vierten Rippe vor deren Vereinigung und zwischen der Fortsetzung dieser Rippen und der Naht, endlich ein sehr kleines Fleckchen vor der Spitze neben der Naht durch aufrechte dunkelbraune Behaarung und etwas dunklere Grundfarbe der Flügeldecken dunkelbraun erscheinend. Die Flügeldecken im übrigen durch anliegende graugelbe und halbanliegende hellbraune Behaarung in helleren Tönen spielend. Kopf grob, tief und unregelmassig punktiert. Zweites und drittes Kiefertasterglied gleich lang, etwa anderthalb so lang wie dick, das letzte etwa anderthalb so lang wie jedes der beiden vorhergehenden, drittehalb so lang wie breit. Fühler kaum merklich länger als der Körper, die Glieder äusserst kurz und breit, erst das 10. deutlich länger als breit. Halsschild sehr breit und kurz, der Vorderrand der Kontur jederseits der Mitte etwas ausgerandet, die Vorderecken der Kontur stark gerundet vorspringend und nach hinten in den äusserst stark entwickelten Seitenrandeindruck übergehend, in dem der Halsschild seine schmalste Stelle erreicht. Die Seiten dann geradlinig erweitert und schliesslich auf der Mitte zwischen Seitenrandeindruck und Basis stumpfwinklig in den fast parallelen, nur unmerklich erweiterten Basalteil übergehend. Die herabgeschlagenen eigentlichen Vorderecken als flache, breite Augenlappen entwickelt. Halsschildpunktierung in den Eindrücken spärlich, im übrigen dicht und fein, die Zwischenräume der Punktierung zum Teil etwas runzlig verfliessend, vor und ausserhalb der Discoidaleindrücke werden diese Runzeln an zwei bis drei Stellen geradezu zu queren bis schrägen Fältchen. Die Discoidaleindrücke breit mit den verhältnismassig tiefen Hintereckeneindrücken verfliessend, innerhalb dieses grossen Eindruckes jedoch nur als kleines, wenig tiefes Grübchen schärfer begrenzt. Halsschild zum Vorderrand kräftig abfallend, im übrigen fast ohne Längswölbung. Schultern wenig breiter als die Halsschildbasis, sehr flach gerundet. Die Flügeldecken bis zur Mitte geradlinig sehr schwach

erweitert, im dritten Viertel leicht gerundet-verengt, im grössten Teil dez letzten Viertels völlig geradlinig zugespitzt und nur die äusserste Spitze wieder abgerundet. Die 1., 2. und 4. Rippe, abgesehen von der Basis sehr stark erhaben, die 1. vor der Einmündung in die 2. verflacht, diese mündet weiter apicalwärts in die 4., und die Vereinigung aller Rippen mündet vor der Spitze, sich verflachend, in den Aussenrand. Hauptpunktierung der Flügeldecken grob und dicht, Grundpunktierung fein, mässig dicht, wenig tief und etwas runzlig. Flügeldecken hinter der Basis stark gewölbt, in der Spitzenhälfte ganz geradlinig abfallend. Schienen und Tarsen schlank, das 2. bis 4. Tarsenglied höher als lang, das 1. etwas länger als das 2. und 3. zusammen, das Klauenglied im Basaldrittel nicht dicker als die vorhergehenden Glieder. Länge 21 mm, Breite der Schultern 5.7, fühlerlänge 21.3.

Die vorgezogene Stirn, die Marmorierung und Rippen der Flügeldecken und die allgemeine Körperform stimmen mit der *dissimilis*-Gruppe überein, doch unterscheidet der starke Seitenrandeindruck, in dem der Halsschild schmaler ist als hinter den Vorderecken, die Art leicht auch von *constricticollis* Emden (1926) und *lagunæ,* denen sie im übrigen am nächsten steht. Auch die geradlinige Zuspitzung der Flügeldecken macht sie leicht kenntlich, in diesem Merkmal kommt ihr am ehesten die viel robustere *C. templetoni* Westwood (= *fasciata* Waterhouse) nahe, die im männlichen Geschlecht durch die Bürste auf dem zwei und drei freien Abdominalsternit von *acutipennis* und allen anderen Arten ganz abweicht.

CALLIRRHIPIS LAGUNÆ Schultze (1916).

Männchen.—Typus: LUZON, Laguna, Paete, Samml. Schultze. Kastanienbraun, die Beine rotbraun, die Tarsen heller braunrot. Pronotum sehr dicht und ziemlich lang, ganz anliegend seidig behaart. Marmorierung der Flügeldecken ziemlich dicht und wurmförmig verschlungen, ein grosses Dreieck an der Basis und ein schräger von vorn innen nach hinten aussen gerichteter Fleck etwa in der Mitte jeder Flügeldecke nicht deutlich gescheckt. Stirn und Scheitel mässig fein, erstere wenig dicht, letzterer dicht punktiert. Das 3. Kiefertasterglied eine Kleinigkeit kürzer und dünner als das 2., reichlich anderthalb so lang wie breit, das 4. etwa ein und zwei Dritteln so lang wie das 3. fast dreimal so lang wie dick. Fühler von Körperlänge, bereits ihr 5. Glied deutlich länger als breit. Halsschild kurz und breit, der Vorderrand der Kontur jederseits der Mitte seicht ausge-

randet, die Vorderecken der Kontur wenig abgerundet, fast stumpfwinklig nach hinten zum Seitenrandeindruck umbiegend. Dieser äusserst breit und sehr tief, jedoch am Grunde etwas weiter von dem der Gegenseite getrennt als die Vorderecken der Kontur. Vom Ende der durch den Seitenrandeindruck bedingten Ausrandung ab ist der Halsschild zur Basis geradlinig erweitert. Die herabgeschlagenen eigentlichen Vorderecken als flache, breite Augenlappen entwickelt. Halsschildpunktierung vorn äusserst fein und äusserst dicht, in der Basalhälfte etwas weniger fein und weniger dicht, in den Discoidaleindrücken zerstreut punktiert. Die Zwischenräume der Punktierung nicht runzelig bis ölig verfliessend. Die Discoidaleindrücke innen ziemlich kräftig eingedrückt, aussen breit mit den Seitenrand und Hintereckeneindrücken verfliessend. Die Präscutellareindrücke beim Typus tief und verschmolzen, mit vertiefter Mittellinie. Halsschild zur Spitze mässig gewölbt, in der Basalhälfte flach. Schultern wenig breiter als die Halsschildbasis, sehr flach gerundet. Flügeldecken bis fast ans Ende des dritten Fünftels fast parallel, von da bis zur Spitze in sehr flachem Bogen gerundet-verengt, die Spitze selbst etwas breiter abgerundet. Die Rippen der Flügeldecken, abgesehen von der Basis, breit und vor der Vereinigung ziemlich stark erhaben, doch wenig scharf abgesetzt. Die Forstsetzung der vereinigten Rippen endet etwa ein Siebentel del Flügeldeckenlänge vor der Spitze frei. Hauptpunktierung der Flügeldecken sehr fein und mässig dicht, Grundpunktierung fein, sehr dicht und tief. Flügeldeckenbasis mässig gewölbt, die zwei apikalen Drittel ohne Längswölbung, nur zur Spitze selbst ganz kurz geneigt. Schienen und Tarsen sehr schlank, das 2. bis 4. Tarsenglied höher als lang, nur an den Vordertarsen das 2. so lang wie hoch, das 1. Glied an den Vordertarsen etwas länger, an den Mittel und Hintertarsen so lang wie oder etwas kürzer als die beiden folgenden zusammen (in der Mitte der Seite gemessen), das Klauenglied der Vorder- und Mittelbeine in der Basalhälfte nicht dicker als die vorhergehenden Glieder. Länge des Typus 16 mm, Schulterbreite 4.3, Fühlerlänge 16.

Etwas kleinere, auffällig schlanke Art der *dissimilis*-Gruppe, noch schlanker als *constricticollis* Emden (1926). Sie ist durch ihre äusserst schlanke Gestalt leicht von allen anderen Arten der *dissimilis*-Gruppe, deren Merkmale sie besitzt, zu unterscheiden. Auch die stark entwickelten Seitenrandeindrücke in Verbindung mit der langen seidigen Pronotum-Behaarung charakterisieren sie gut.

Ausser dem Typus lag mir ein Männchen vom Museum Stettin vor mit dem Fundort "Philippinen." Es weicht durch etwas weniger lange Fühler, vorn nicht ganz so breiten und eckigen Halsschild, sehr schwachen, durch einen feinen Mittelkiel geteilten Präscutellareindruck und halbmondförmige Discoidaleindrücke desselben und etwas gröbere Marmorierung der Flügeldecken etwas ab. Im Städtischen Museum für Natur-, Völker- und Handelskunde, Bremen, befindet sich ein kleines Männchen: Philippinen (*O. Schütze*), von 14.5 mm länge, während das Exemplar des Stettiner Museums 17.7 mm misst.

CALLIRRHIPIS SCHULTZEI sp. nov.

Zwei Männchen und Weibchen. PANAY, Antique, Culasi, Samml. W. Schultze (männlicher Typus jetzt Mus. Dresden, männlicher Paratypus und weiblicher Typus in Samml. W. Schultze).

Männchen.—Kastanienbraun, Flügeldecken grösstenteils, Bauch und Schenkel etwas heller, Schienen, Tarsen und Fühler hell rotbraun. Behaarung goldgelb bis graugelb, auf dem Halsschild ziemlich lang und fast anliegend, auf den Flügeldecken wenig lang doch länger als bei den meisten anderen Arten, die Lagerung auf den Decken vielfach wechselnd und infolgedessen eine dichte und kräftige Scheckung erzeugend, die sehr auffällig ist. Kopf ziemlich fein und sehr dicht punktiert. Drittes Glied der Kiefertaster zwei Dritteln so lang wie das 2. anderthalbmal so lang wie breit, das 4. knapp dreimal so lang wie breit. Fühler reichlich vier Fünfteln so lang wie der Körper. Schon das 5. Fühlerglied deutlich etwas länger als breit. Halsschild mässig lang, vorn stark gerundet, die Rundung jederseits der Mitte etwas abgeflacht, jedoch die Kontur nicht ausgeschweift, die Seiten durch den mässig entwickelten Seitenrandeindruck schmal aber nicht sehr flach ausgerandet, vom Seitenrandeindruck bis zur Basis fast geradlinig gleichmässig, ziemlich stark erweitert, am Vorderrand innerhalb der Vorderecken (die eigentlichen Vorderecken jedoch nicht eingerechnet) halb so breit wie an der Basis. Die herabgeschlagenen eigentlichen Vorderecken, die breit von oben sichtbar sind, kräftig gerundet als starke Augenlappen vorgezogen. Halsschildpunktierung äusserst fein und mässig dicht, die Zwischenräume der Punktierung nirgends ölig verfliessend. Präscutellareindrücke fast erloschen, Discoidaleindrücke gross und sehr tief, am Grunde fast unpunktiert, nach innen sehr scharf begrenzt, nach aussen etwas mit den verhältnismässig stark entwickelten Hinterecken-

eindrücken verfliessend. Halsschild in der ganzen Länge ziemlich gleichmässig wenig stark gewölbt. Schultern deutlich breiter als die Halsschildbasis, kräftig gerundet. Die Flügeldecken bis ans Ende des vierten Siebentels schwach gerundet erweitert, von da zur Spitze in sehr flacher Rundung gleichmässig verengt, die Spitze abgerundet. Die Rippen ausser der 3. stark erhaben, gleich hinter der Schulter als breite Erhöhungen hervortretend, ziemlich breit, durch begleitende unregelmässige Punktreihen ziemlich scharf begrenzt. Die gemeinsame Verlängerung zieht schräg zum Aussenrand. Hauptpunktierung sehr fein, bis auf die ziemlich groben Reihen entlang den Rippen. Grundpunktierung wenig fein, dicht und ziemlich tief. Das Basaldrittel der Flügeldecken (besonders die Naht) mit kräftiger Längswölbung, das folgende Drittel der Länge nach fast eben, das letzte flach zur Spitze abwärts gewölbt. Schienen und Tarsen sehr schlank, das 1. Glied beim Typus fast so lang wie die drei folgenden zusammen, beim Paratypus so lang wie die zwei folgenden zusammen, das 2. bis 4. Glied der Vordertarsen beim Typus länger als hoch, beim Paratypus fast so lang wie hoch. Länge 19.1 bis 21.4 mm, Schulterbreite 5.3 bis 6.2, Fühlerlänge 16.8 bis 17.8. (Das erste Mass bezieht sich jeweils auf den Typus.)

Weibchen.—Dem Weibchen von *grandicornis* Emden (1926) sehr ähnlich, doch der Halsschild viel weniger kurz (anderthalb mal so breit wie lang, bei *grandicornis* fast ein und drei Vierteln mal und die Flügeldecken viel kürzer gebaut, viermal so lang wie der Halsschild (bei *grandicornis* fast fünfmal), auch in den Zwischenräumen der Rippen stark glänzend. Vom Weibchen der *C. longitarsis* durch an der Spitze schmäleren Halsschild, sehr stark entwickelte Flügeldeckenrippen und zur Spitze mehr geradlinig verengte Flügeldecken auffällig verschieden. Merkmale der *dissimilis*-Gruppe: Braunschwarz gefärbt, Kopf ziemlich grob und ungleichmässig wenig dicht punktiert. Fühlerlamellen wenig lang, die des 5. Fühlergliedes fast doppelt so lang wie das zugehörige Glied. Halsschild vorn mässig breit gerundet, die Vorderrand-Kontur jederseits der Mitte kurz aber deutlich ausgerandet. Seitenrandeindruck schmal aber deutlich, die Halsschildseiten von da bis zu den Hinterecken fast geradlinig schwach erweitert. Scheibe fein und zerstreut, deutlich doppelt punktiert, die feineren Punkte (Grundpunktierung) eingestochen und verhältnismässig kräftig, doch sehr spärlich. Alle Eindrücke scharf getrennt. Discoidaleindrücke tief und rundlich, wenig gross, Präscutellareindrücke ziemlich flach.

Schildchen fein und äusserst zerstreut punktiert. Flügeldecken mit breiten, nach hinten stark erhabenen, wenn auch nicht sehr scharf begrenzten Rippen, deren gemeinsame Verlängerung kurz vor der Spitze wenig deutlich in den Aussenrand mündet. Seitenrand bis fast zur Spitze durch eine tiefe Randkehlung abgesetzt und kräftig aufgebogen (bei *grandicornis* vom Beginn des vierten Fünftels ab nur noch undeutlich wulstförmig abgesetzt), bis gegen die Mitte etwas schmäler als die Randkehle. Flügeldecken mit ziemlich breiten Schultern, dahinter lang und leicht ausgeschweift, zum Ende des zweiten Drittels ziemlich stark erweitert und dann ziemlich plötzlich in sehr flacher Rundung zur Spitze umbiegend. Flügeldecken auf der Basalwölbung nur mit ganz vereinzelten feinen Punkten, die Hauptpunktierung im übrigen ziemlich fein, etwas ungleich, gegen die Spitze ein wenig runzlig, die Grundpunktierung fein und äusserst zerstreut, die Rippen infolgedessen wie der Halsschild mit Hochglanz, die Zwischenräume matter glänzend, jedoch nicht matt, wie es bei *grandicornis* der Fall ist. Tarsen schlank, das Klauenglied zur Spitze etwas mehr verdickt als bei *longitarsis,* jedoch viel schlanker als bei *grandicornis.* Das 2. bis 4. Tarsenglied viel höher als lang. Länge 23.9 mm, Schulterbreite 7.3.

Durch den nach vorn stärker verengten Halsschild mit tiefen Discoidaleindrücken, kräftige Flügeldeckenrippen und schlanke Tarsen sowie im männlichen Geschlecht lange Fühler kenntlich.

CALLIRRHIPIS LONGITARSIS sp. nov.

Zwei Männchen und 1 Weibchen, PANAY, Antique, Culasi, Samml. W. Schultze (männlicher Typus jetzt Mus. Dresden, männlicher Paratypus und weiblicher Typus in Samml. W. Schultze).

Männchen.—Dunkel kastanienbraun, die Flügeldecken zur Spitze etwas heller, Tarsen und Fühler hell rotbraun, beim Paratypus rotbraun. Behaarung goldgelb bis graugelb, die Flügeldecken dicht und fein, doch wenig auffällig marmoriert. Kopf ziemlich grob und dicht punktiert, 3. Glied der Kiefertaster so lang wie das 2., anderthalb mal so lang wie breit, das 4. reichlich anderthalb mal so lang, kaum mehr als zweimal so lang wie breit. Fühler fast von Körperlänge oder doch (Paratypus) von drei Vierteln der Körperlänge. Erst das 8. Fühlerglied deutlich länger als breit. Halsschild mässig kurz, vorn breit und jederseits der Mitte flacher gerundet, jedoch die Kontur nicht ausgeschweift, die Seiten durch den flachen Seitenrandeindruck

nur flach ausgerandet (beim Paratypus der Seitenrandeindruck fast erloschen), vom Eindruck bis zur Basis fast geradlinig erweitert. Die herabgeschlagenen Vorderecken als breit gerundete Augenlappen schwach vorragend. Halsschildpunktierung ziemlich fein, zur Basis noch feiner werden, beim Typus dicht, beim Paratypus wenig dicht, die Zwischenräume der Punktierung bei diesem zum Teil etwas ölig verfliessend. Discoidal und Präscutellareindrücke beim Typus sehr flach, beim Paratypus tief, die Hintereckeneindrücke bei beiden verhältnismässig tief, alle Eindrücke gut voneinander getrennt. Halsschild in den apikalen zwei Dritteln ziemlich kräftig gewölbt, im Basal drittel eben. Schultern wenig breiter als dei Halsschildbasis, breit gerundet. Die Flügeldecken bis zum Ende des vierten Siebentels sehr schwach gerundet-erweitert, fast geradlinig und fast parallel, von da zur Spitze gleichmässig gerundet-verengt, die Spitze abgerundet. Die Rippen nur mässig erhaben, doch durch eine nicht ganz regelmässige Punktreihe jederseits deutlich begrenzt. Die gemeinsame Verlängerung der Rippen ist schräg nach hinten zum Aussenrand gerichtet, erreicht diesen jedoch nicht. Hauptpunktierung sehr fein (Typus) bis mässig fein (Paratypus), Grundpunktierung ziemlich fein, ziemlich dicht und wenig tief. Die Fläche zwischen den Rippen unregelmässig geknittert, viel mehr als bei den meisten anderen philippinischen Arten. Die Längswölbung flach und bis zur Spitze ziemlich gleichmässig, nur im mittleren Drittel fast eingeebnet. Schienen und Tarsen sehr schlank, beim Paratypus nur mässig schlank, das 1. Glied der Tarsen in der Mitte der Seiten so lang wie die drei folgenden Glieder zusammen. Das 2. Glied beim Typus an den Vorder- und Mittelbeinen länger als hoch, beim Paratypus an allen Beinen höher als lang, dementsprechend ist beim Typus das 3. and 4. Vordertarsenglied etwa so lang wie hoch oder doch wenig höher als lang, beim Paratypus viel höher als lang. Länge 17.8 bis 22.2 mm, Schulterbreite 4.6 bis 6.3, Fühlerlänge 17.5 beziehungsweise 16.7. (Das erste Mass bezieht sich stets auf den Typus, das zweite auf den Paratypus).

Wenn nicht auch bein *schultzei* eine beträchtliche, obwohl nicht ganz so grosse Variation in der Lange der Tarsenglieder festzustellen wäre, hätte ich diese beiden Männchen zwei verschiedenen Arten zugerechnet. Auch die übrigen Merkmale der beiden Stücke, die nicht ganz übereinstimmen, sind bei anderen Arten schon als variabel festgestellt worden (Fühlerlänge, Punktierung), an der Artgleichheit ist demnach trotz der Ver-

schiedenheiten kaum zu zweifeln. Das nachstehend beschriebene Weibchen schliesst sich mehr dem Typus an. Die Verlängerung der Tarsenglieder tritt bei den *Callirrhipis* Weibchen wie im gleichen Masse ein wie bei den Männchen.

Weibchen.—Den Weibchen von *C. javanica* Castelnau sehr ähnlich, sogar noch feiner punktiert und noch glänzender, doch viel robuster, grösser und durch die Merkmale der *dissimilis*-Gruppe (plattenförmig vorgezogenen vorderen Teil der Stirn und fehlende Seitenecke des Ovipositors) von ihm verschieden. Das einzige Stück ist rötlich kastanienbraun gefarbt. Kopf ziemlich grob punktiert. Die Fühlerlamellen sehr kurz, die des 5. Fühlergliedes knapp ein Viertel länger als das zugehörige Glied. Halsschild kurz und breit, reichlich anderthalb mal so breit wie lang, vorn sehr breit gerundet und jederseits der Mitte nicht ausgeschweift. Seitenrandeindruck sehr flach, die Seiten unmittelbar vor den Hinterecken kurz, doch ziemlich kräftig ausgeschweift. Halsschild fein und zerstreut, doch ziemlich gleichmässig punktiert. Discoidaleindrücke fehlen, die übrigen Eindrücke breit und deutlich. Schildchen sehr fein und äusserst zerstreut punktiert, der Grund von Halsschild und Schildchen mit Spuren einer ganz erloschenen, auf dem Schildchen etwas deutlicheren Punktulierung, die nur bei bestimmter Beleuchtung erkennbar sind. Flügeldecken in der Basalhalfte nicht gröber punktiert als der Halsschild, vor der Spitze mehr als doppelt so grob, die Hauptpunktierung jedoch überall ausserordenlich fein, die Grundpunktierung ganz vereinzelt und wenig fein. Die Rippen im Basaldrittel ganz erloschen, im übrigen schwach und breit erhaben, unscharf abgegrenzt. Seitenrand der Flügeldecken bis fast zur Spitze durch eine tiefe Kehle abgesetzt, diese zur Spitze nur wenig verbreitert, der Seitenrand nach hinten ebenfalls nur wenig verbreitert, in der ganzen Länge bis auf die äusserste Spitze scharf wulstförmig (gegen die Spitze als Aufbiegung) von der Randkehle abgesetzt und überall ebenso breit wie diese. Flügeldecken zum Ende des zweiten Drittels kräftig erweitert, dann stark gerundet verengt, an der Spitze breit abgerundet. Tarsen schlank. Das 1. Glied der Vordertarsen (in der Mitte der Seiten gemessen) etwas länger als die beiden folgenden zusammen, das 2. bis 4. Glied höher als lang. Länge 20.5 mm, Schulterbreite 6.1.

Durch die langen Fühler und das längere 1. Tarsenglied von *parallela* leicht zu unterscheiden, der *longitarsis* sonst im männlichen Geschlecht recht nahe steht. Im weiblichen Geschlecht

durch die extrem feine Hauptpunktierung der Flügeldecken, die diese an der Basis fast poliert erscheinen lasst, die scharfe Randung der Flügeldeckenseiten, die breit gerundete, fast gemeinsam etwas abgestutzte Flügeldeckenspitze und die kurzen Fühlerlamellen sehr ausgezeichnet.

CALLIRRHIPIS GRISEA sp. nov.

Männchen.—MINDORO, Abra de Ilog. Samml. W. Schultze. Schwarzgrau, die Tarsen und das 2. Fühlerglied kastanienbraun, der Rest der Fühler dunkelgraubraun gefärbt. Behaarung graugelb bis goldgelb, verschieden gelagert, sodass die Flügeldecken graugelb und dunkel gelblichgrau marmoriert erscheinen, diese Marmorierung deutlich, doch nicht sehr auffällig. Stirn über den Fühlern zerstreut und unregelmässig grob punktiert und gerunzelt, Scheitel dicht und regelmässig wenig grob, doch tief punktiert. Das 3. Kiefertasterglied etwa ein Zehntel kürzer als das 2., knapp ein Drittel länger als breit, das 4. etwa anderthalbmal so lang wie das 3., knapp drittehalbmal so lang wie dick. Fühler reichlich halb so lang (0.56 : 1) wie der Körper, erst das 7. Fühlerglied deutlich länger als breit. Halsschild kurz und breit, vorn breit und gleichmässig gerundet, die Seiten fast winklig ansetzend, am Seitenrandeindruck in grösser Ausdehnung fast geradlinig und nur unmerklich breit ausgerandet, da dieser flach und zudem mehr auf die Dorsalseite gerückt ist, in der Mitte zwischen Seitenrandeindruck und Basis fast stumpfwinklig umbiegend und bis zur Basis geradlinig nur noch ziemlich schwach erweitert. Die herabgeschlagenen Vorderecken als breite Augenlappen schwach vorragend. Halsschildpunktierung etwas ungleich, überall fein und wenig dicht, besonders in den Eindrücken und in der Mitte der Scheibe spärlicher, die Zwischenräume der Punktierung mit Ausnahme des herabgeschlagenen Pronotumteils nirgends runzlig oder ölig zusammenfliessend, kaum stellenweise etwas gewölbt. Die Halsschildeindrücke gut abgegrenzt, die Discoidaleindrücke rundlich und tief, auch die länglichen Hintereckeneindrücke verhältnismassig ziemlich tief. Halsschild in der Apikalhälfte mässig gewölbt, in der Basalhälfte flach. Schultern wenig breiter als die Halsschildbasis, breit gerundet. Die Flügeldecken bis zum Ende des vierten Siebentels etwas erweitert, die Seiten bis dahin sehr schwach gerundet, von da zur Spitze gleichmässig gerundet verengt, die Spitze selbst kurz abgerundet. Die 1., 2. und 4. Rippe, abgesehen von der Basis, ziemlich breit und gleichmässig,

doch wenig stark erhaben. Die gemeinsame Verlängerung der vereinigten Rippen mündet, sich verflachend, undeutlich in den Aussenrand. Hauptpunktierung der Fügeldecken fein und mässig dicht, Grundpunktierung mässig fein, flach und wenig dicht. Die Längswölbung der Flügeldecken ziemlich erheblich und gleichmässig bis zur Spitze fortgesetzt. Schienen und Tarsen ziemlich schlank, das 2. Glied der Tarsen etwas kürzer als das 2. und 3. zusammen, das 2. bis 4. an den Mittel- und Hintertarsen etwa doppelt so hoch wie einzeln lang. Das Klauenglied ziemlich robust. Länge 19.5 mm, Shulterbreite 6, Fühlerlänge 11.0.

Die Art besitzt alle Merkmale der *dissimilis*-Gruppe. In ihr ist sie ausser durch die schwarzgraue Färbung durch die auffallend kurze und robuste Gestalt leicht kenntlich. Von der einzigen ähnlich kurzen Art *templetoni* Westwood unterscheidet sie sich ausser durch die Färbung und Skulptur durch die gerundete Aussenseite der Flügeldeckenspitze und das Fehlen der Bürste auf dem zweiten und dritten freien Abdominalsternit.

CALLIRRHIPIS BAKERI sp. nov.

Männchen.—INSEL SAMAR (*Baker*). Kastanienbraun, die Fühler vom 2. Glied ab lichtbraun. Behaarung goldgelb bis hellbraun, die Flügeldecken durch ihre wechselnde Legerung dicht und ziemlich fein, sehr auffällig gescheckt. Kopf bis auf die weitgehend geglättete Mitte der Stirn sehr dicht und ziemlich fein punktiert. Drittes Glied der Kiefertaster etwas kürzer und etwas schmäler als das 2., ein und ein Viertelmal so lang wie breit, zur Spitze ebenso wie das 2. ziemlich stark verbreitert, das 4. ein und zwei Drittelnmal so lang wie das 3., drittehalbmal so lang wie breit. Fühler sieben Zehnteln so lang wie der Körper, 2. bis 8. Fühlerglied stark quer, das 9. schwach quer, das 10. etwas länger als breit, die Lamellen in der Mitte ihrer Länge anderthalbmal so breit wie nahe Basis und Spitze. Halsschild kurz, vorn breit und jederseits der Mitte flacher gerundet, die Kontur dort wenig deutlich ausgeschweift. Die Seiten durch den flachen und wenig scharf begrenzten Seitenrandeindruck schwach ausgeschweift, dahinter durch die äusserst grobe höckerige Runzelung der Seitenflächen im Profil mit drei bis fünf flachen Höckerchen, gegen die Hinterecken flach gerundet erweitert, die Hinterecken selbst sehr schwach eingezogen. Die herabgeschlagenen Vorderecken als gerundete Augenlappen ziemlich kräftig vorragend, bei binokularer dorsaler Betrachtung durch die breit vorstehenden abgerundet-stumpfwinkligen

Konturvorderecken verdeckt. Halsschildpunktierung sehr fein und wenig dicht, zur Mitte der Basis äusserst fein und spärlich werdend, die Zwischenräume der Punktierung nach vorn zu vielfach öligverfliessend. Präscutellareindrücke sehr gross und tief, kaum weniger tief als die kleinen, runden aber ziemlich tiefen und ringsum gut begrenzten Discoidaleindrücke. Vor und ausserhalb jedes Discoidaleindruckes befindet sich ein weiterer ähnlicher runder und ziemlich tiefer (vielleicht nur monströser?) Eindruck. Hintereckeneindrücke breit und deutlich, mässig tief, nach vorn und aussen mit einigen groben, breiten Runzeln. Halsschild in den apikalen drei vierteln ziemlich gleichmässig und wenig stark gewölbt, am Beginn des Basalviertels sehr flach eingesattelt und unmittelbar an der Basis wieder etwas konvex gewölbt. Schildchen kaum breiter als lang, vor der Mitte am breitesten und nach hinten abgerundet-zugespitzt, sehr fein und ziemlich dicht punktiert. Schultern breit gerundet, wenig breiter als die Halschildbasis. Flügeldecken bis zum Ende des vierten Siebentels deutlich ausgeschweift-erweitert, von da zur Spitze gleichmässig in flacher Rundung verengt, am Ende ziemlich spitz abgerundet. Die 1., 2. und 4. Rippe von der Mitte bezüglich von vor der Mitte bis zu ihrer Vereinigung sehr breit und stark dachförmig erhaben, die Punkte in den die eingentlichen Rippen begrenzenden Punktreihen zwar ziemlich grob, doch wenig dicht und wenig regelmässig angeordnet, der Kamm der Rippen infolgedessen unscharf in die dachförmig abfallenden benachbarten Teile der Zwischenräume übergehend. Die gemeinsame Verlängerung der Rippen ist schräg nach hinten zum Aussenrand erichtet, erlischt jedoch in der Absetzung des Seitenrandes. Hauptpunktierung mässig fein und mässig dicht. Grundpunktierung ziemlich fein und ziemlich dicht. Die Fläche zwischen den Rippen wenig stark unregelmässig geknittert. Die Längswölbung in der Basalhälfte stark, in der Apikalhälfte schwach und nur vor der Spitze wieder deutlicher, die Naht im fünften Siebentel sogar etwas eingedrückt, die Querwölbung der Flügeldecken ziemlich stark. Schienen und Tarsen mässig schlank, Tarsen viel kürzer als die Schienen, die ersten vier Tarsenglieder viel höher als lang, zusammen viel kürzer als das Klauenglied. Länge 24.5 mm, Schulterbreite 7.1, Fühlerlänge 17.0.

Durch ihre Grösse, robuste Gestalt, die breiten, starken Rippen, die akzessorischen Halsschildeindrücke und die starke Runzelung der Seitenflächen des Halsschildes ist diese Art von allen anderen Arten ihrer Gruppe leicht zu unterscheiden.

CALLIRRHIPIS PARALLELA sp. nov.

Männchen und Weibchen. NEGROS, Cuernos Mts. (*Baker*, Männchen, *20965*).

Männchen.—Dunkel kastanienbraun, Beine kastanienbraun, Fühler lichtbraun. Behaarung goldgelb bis grau goldgelb, die Flügeldecken dicht und fein doch nich sehr auffällig gescheckt erscheinend. Kopf ziemlich grob und äusserst dicht punktiert. Drittes Glied der Kiefertaster so lang und breit wie das 2., wenig länger als an der Spitze breit, dort wesentlich breiter als an der Basis, das 4. reichlich anderthalbmal so lang, zweimal so lang wie breit. Fühler drei Fünfteln so lang wie der Körper, das 7. Glied etwa so lang wie breit, die folgenden länger als breit. Halsschild sehr kurz und breit, doppelt so breit wie lang, vorn in der Mitte sehr breit gerundet, seitlich davon ziemlich kräftig ausgeschweift, die Konturvorderecken fast stumpfwinklig. Die Seiten an den kleinen, doch kräftigen und ziemlich scharf begrenzten Seitenrandeindrücken in der Kontur nicht ausgerandet, vom Eindruck bis zu den nicht eingezogenen Hinterecken in sehr flacher Rundung erweitert, unmittelbar an der Basis am breitesten. Die herabgeschlagenen Vorderecken als sehr breit gerundete Augenlappen schwach vorragend, ihr Vorderrand bei binokularer, dorsaler Betrachtung des Halsschildes gerade zu erkennen. Halsschildpunktierung ziemlich fein und mässig dicht, zur Basis sehr fein werdend, die Zwischenräume der Punktierung auf der Scheibe vielfach runzlig bis ölig verfliessend. Discoidaleindrücke sehr tief, Präscutellareindrücke gross und ziemlich tief, Hintereckeneindrücke deutlich und ebenfalls verhältnismässig tief, alle Eindrücke gut voneinander getrennt. Halsschild in den apikalen drei Vierteln ziemlich flach gewölbt, im Basalviertel eben, Schultern sehr wenig breiter als die Halsschildbasis, sehr flach gerundet, die Flügeldecken sehr schlank, zwei und drei Vierteln so lang wie zusammen an den Schultern breit, bis zum Ende des zweiten Viertels äusserst flach und gleichmässig gerundet, dem unbewaffneten Auge bis dahin völlig parallel erscheinend, von da in flachem Bogen zur Spitze verengt, kurz vor der Spitze stärker gerundet, diese selbst aber nur schmal abgerundet. Die Rippen sehr flach und breit, überall unscharf in die Zwischenräume übergehend, die begrenzenden Punktreihen mässig deutlich, an der Basis wöllig eingeebnet, bis zur Mitte äusserst schwach erhaben, nur die 2. und 4. vor der Vereinigung etwas stärker hervortretend, die gemeinsame Verlängerung undeutlich. Die Zwischenräume der Rippen in der Basalhälte eben, nur stellenweise fast unmerklich konkav,

vor der Vereinigung der Rippen schwach konkav. Hauptpunktierung ziemlich fein und wenig dicht, sehr gleichmässig, und der Grund zwischen ihr nur äusserst schwach geknittert. Grundpunktierung ziemlich fein, mässig dicht und wenig tief. Flügeldecken im Basal- und Apicaldrittel mit kräftiger Längswölbung, das mittlere Drittel fast eben, Querwölbung ziemlich stark. Schienen und Tarsen wenig schlank, das erste Glied der letzteren etwa so lang wie die zwei folgenden zusammen, diese und das 4. höher als lang. Länge 18 mm, Schulterbreite 4.8, Fühlerlänge 10.8.

Weibchen.—Durch die sehr schlanken Flügeldecken mit schwach entwickelten Rippen und—auch vor der Vereinigung der letzteren—äusserst schwacher Konkavwölbung viel mehr an die Weibchen der *trepida*-Gruppe als die der *dissimilis*-Gruppe erinnernd, doch schon nach der Bildung des Stirnvorderteils als zu letzterer Gruppe gehörig erkennbar. Kopf ziemlich grob und ungleichmässig punktiert. Fühlerlamellen lang und sehr eng gestellt, die des 5. Gliedes fünftehalbmal so lang wie das zugehörige Glied, das 11. Glied langgestreckt, linear, etwas länger als das 7. bis 10. Glied zusammen, das 4. Glied etwa so lang wie breit, das 5. bis 10. länger als breit. Halsschild in der Anlage dem des Männchen ähnlich, doch etwas breiter und etwas gleichmässiger gewölbt, mit weniger starken, doch immer noch kräftigen Eindrücken, zerstreut und ungleichmässig punktiert, hinten an den Seiten fein runzlig. Zwischen der verhältnismässig feinen Hauptpunktierung findet sich eine äusserst flache, fast erloschene, doch wenig feine und mässig dichte Grundpunktierung. Schildchen ähnlich wie beim Männchen doch viel breiter, spärlich und sehr fein punktiert, mit erloschener Grundpunktierung dazwischen. Flügeldecken bis zum Ende des zweiten Drittels leicht erweitert, dann in ziemlich flacher Rundung gleichmässig verengt, Rippen in der Basalhälfte kaum merklich, in der Apikalhälfte schwach erhaben, die gemeinsame Verlängerung deutlich, nach dem Aussenrand gerichtet, ihn jedoch nicht deutlich erreichend. Hauptpunktierung mässig fein, etwas nadelrissig, gegen die Spitze runzlig. Grundpunktierung wenig fein aber äusserst zerstreut und daher leicht zu übersehen. Schienen und Tarsen wenig schlank. Länge 26 mm, Schulterbreite 7.7, Fühlerlänge 6.

Diese Art ist durch die schlanke, parallele Gestalt bei schwach ausgeprägten Rippen der Flügeldecken und wenig langen Fühlern und kurzen Tarsen kenntlich.

CALLIRRHIPIS LUZONICA sp. nov.

Männchen. LUZON, Tayabas, Malinao (*Baker*).

Männchen.—Dunkel kastanienbraun, die Flügeldecken gegen die Spitze, die Unterseite, Tarsen und Fühlerlamellen etwas heller. Behaarung bräunlich-goldbelb bis grau-goldgelb, die Flügeldecken dicht und fein gescheckt erscheinend. Kopf wenig grob und ziemlich dicht punktiert. Drittes Glied der Kiefertaster so lang und breit wie das 2., an der Spitze so breit wie lang, dort wesentlich breiter als an der Basis, das 4., ein und drei Viertelnmal so lang, zweimal so lang wie breit. Fühler reichlich halb so lang wie der Körper (0.51 : 1), das 7. Glied etwas so lang wie breit, die folgenden länger als breit. Halsschild mässig kurz, reichlich anderthalbmal so breit wie lang, vorn in der Mitte breit gerundet, seitlich davon geradlinig abgeschrägt, nicht merklich ausgerandet, die Konturvorderecken abgerundet. Die Seiten an den sehr flachen, breiten Seitenrandeindrücken in der Kontur nicht ausgerandet, bis zu den nicht eingezogenen Hinterecken in sehr flacher Rundung erweitert, unmittelbar an der Basis am breitesten. Die herabgeschlagenen Vorderecken als sehr breit gerundete Augenlappen schwach vorragend, ihr Vorderrand bei dorsaler binokularer Betrachtung eben sichtbar. Halsschildpunktierung ziemlich fein und mässig dicht, zur Mitte der Basis feiner, nach aussen etwas gröber werdend, die Zwischenräume vorn auf der Scheibe sehr wenig ölig erhaben, an den Seiten ausserhalb der Discoidaleindrücke etwas runzlig verfliessend. Discoidaleindrücke mässig gross, ziemlich tief, Präscutellareindrücke ziemlich gross und ziemlich tief, Hintereckeneindrücke deutlich und ebenfalls verhältnismässig tief. Letztere von den Discoidaleindrücken wenig scharf getrennt, die Eindrücke im übrigen gut voneinander getrennt. Halsschild in den apikalen zwei Dritteln ziemlich flach gewölbt, im Basaldrittel eben. Schultern wenig breiter als die Halsschildbasis, flach gerundet, die Flügeldecken ziemlich robust, zwei und zwei Drittelnmal so lang wie zusammen an den Schultern breit, bis zum Ende des dritten Fünftels schwach ausgeschweift-erweitert, dann in sehr schwachem Bogen, weiterhin fast geradlinig, am Ende wieder flach gerundet zugespitzt, die Spitze selbst ziemlich schmal abgerundet. Die Rippen breit und stark erhaben, allmählich in die konkaven, ziemlich grob geknitterten Zwischenräume übergehend, die begrenzende Punktreihe jederseits wenig regelmässig, die gemeinsame Verlängerung der Rippen wenig deutlich, sie strebt dem Aussenrand zu, erlischt jedoch

vorher. Die Zwischenräume der Rippen in der Basalhälfte deutlich, in der Apikalhälfte kräftig konkav. Hauptpunktierung wenig grob und mässig dicht, etwas ungleichmässig. Grundpunktierung wenig fein, mässig dicht, ziemlich tief. Flügeldecken in der Basalhälfte mit ziemlich kräftiger Längswölbung, in der Apikalhälfte der Länge nach fast eben und nur zur Spitze wieder leicht abwärts gewölbt. Querwölbung wenig stark. Schienen und Tarsen wenig schlank, das 1. Glied der letzteren etwa so lang wie die zwei folgenden zusammen, diese und das 4. höher als lang. Länge 18.8 mm, Schulterbreit 5.4, Fühlerlänge 10.8.

Unter den Arten der *dissimilis*-Gruppe mit verhältnismässig kurzen männlichen Fühlern durch kräftige Rippen der Flügeldecken und die in der Mitte des Halsschildes nicht runzlig und kaum ölig verfliessenden Zwischenräume der Punktierung gekennzeichnet. Der *C. dissimilis* sehr ähnlich, doch von ihr und *antennaria* durch viel robustere, an der Spitze stärker nach aussen gebogene Schienen und robustere Körperform, auf der parallelen Stirn breiter getrennte Augen und weniger kurzen Halsschild unterschieden.

CALLIRRHIPIS RUGICOLLIS sp. nov.

Drei Männchen, 2 davon "Philippinen," 1 "Luzon," Naturkunde-Museum Stettin.

Männchen.—Rötlich kastanienbraun, Kopf, Halsschild und Unterseite der Brust etwas dunkler. Behaarung bräunlich goldgelb, die Flügeldecken dicht und fein gescheckt erscheinend. Kopf grob und dicht punktiert. Drittes Glied der Kiefertaster ein Fünftel kürzer als das 2., ebenso breit, ein Achtel länger als breit, das vier und ein Achtel schmäler, reichlich zwei und zwei Drittelnmal so lang wie breit. Fühler drei Fünfteln bis zwei Dritteln so lang wie der Körper (0.63-0.67), erst das 8. bis 9. Glied länger als breit. Halsschild ziemlich kurz und breit, reichlich ein und drei Fünftelnmal so breit wie lang, nach vorn ziemlich stark verengt, vorn in der Mitte flach gerundet, seitlich davon abgeschrägt, die Kontur nicht merklich ausgerandet, die Konturvorderecken breit abgerundet Die Seiten an den flachen Seitenrandeindrücken in der Kontur nicht ausgerandet, bis zu den nicht eingezogenen Hinterecken gerundet–erweitert, unmittelbar an der Basis am breitesten. Die herabgeschlagenen Vorderecken als breit gerundete Augenlappen schwach vorragend, bei dorsaler binokularer Betrachtung deutlich sichtbar. Halsschildpunktierung mässig fein und mässig dicht, zur Basis

feiner werdend, die Zwischenräume überall stark ölig verfliessend, an den Seiten von den Hintereckeneindrücken ausgehend stark runzlig verbunden. Discoidaleindrücke mässig gross, tief, Präscutellareindrücke mässig gross und ziemlich tief, Hintereckeneindrüke gross und verhältnismässig tief, von den Discoidal- und Seitenrandeindrücken wenig scharf getrennt, die Eindrücke im übrigen gut voneinander geschieden. Halsschild in den apikalen zwei Dritteln ziemlich flach gewölbt, im Basaldrittel eben. Schultern etwas breiter als die Halsschildbasis, breit gerundet, die Flügeldecken mässig robust, zwei und zwei Drittelnmal so lang wie an den Schultern zusammen breit, bis zum Ende des dritten Fünftels schwach ausgeschweift erweitert, dann in sehr flachem Bogen verengt, am Ende kurz abgerundet-zugespitzt. Die Rippen wenig breit und wenig stark erhaben, jederseits durch eine ziemlich regelmässige Punktreihe sehr scharf von den schwach konkaven, ziemlich fein geknitterten Zwischenräumen abgegrenzt. Die gemeinsame Verlängerung der Rippen erreicht die Seitenrandkehle, ohne an den Rand selbst zu gelangen. Hauptpunktierung grob und dicht, etwas ungleichmässig. Grundpunktierung wenig fein, mässig dicht, ziemlich tief, die Zwischenräume leicht querrunzelig verbunden. Flügeldecken in den basalen zwei Fünfteln mit ziemlich kräftiger Längswölbung, in den folgenden zwei Fünfteln fast eben, im Apikalfünftel zur Spitze flach abswärts gewölbt, unmittelbar vor dem Ende ist die Kontur flach ausgerandet. Querwölbung wenig stark. Schienen und Tarsen wenig schlank, das 1. Glied der letzteren etwa so lang wie die zwei folgenden zusammen, diese und das 4. viel höher als lang. Länge 20.5 bis 22.5 mm, Schulterbreite 6.1 bis 6.6, Fühlerlänge 13 bis 15.

Noch näher mit *C. dissimilis* verwandt als die vorige Art, von ersterer durch bedeutendere Grösse, robustere, zur Spitze stärker erweiterte und mehr nach aussen gebogene Schienen und stärker zugespitzte Flügeldecken unterschieden.

CALLIRRHIPIS HELLERI Schultze (1915).

Männchen (*Typus*).—LUZON, Laguna, Paete, Samml. Schultze. Auffällig grosse Form der *trepida*-Gruppe mit sehr feiner Punktierung, doch ohne Knitterung der Flügeldecken. Halsschild nur 1.32 mal so breit wie lang, also auffällig lang, nach vorn mässig verengt, vorn sehr breit gerundet, mit erloschenem Seitenrandeindruck, ziemlich kräftigen Discoidal- und ziemlich flachen Präscutellareindrücken, sehr fein und wenig dicht punktiert. Flügeldecken von Form und Behaarung der *trepida*-

Gruppe, Rippen leicht erhaben, Hauptpunktierung fein und wenig dicht, etwas ungleichmässig. Grundpunktierung äusserst fein, eingestochen, wenig dicht. Fühler sehr lang. Parameren und Penis ähnlich wie bei *dissimilis,* doch robuster und erstere deutlicher einwärts gebogen, weniger zugespitzt. Die fünf (davon ein jetzt im Museum für Tierkunde zu Dresden) männliche Stücke des Städtischen Museums für Natur-, Völker- und Handelskunde, Bremen, sind wesentlich kleiner als der Typus, sodass die Art für die *trepida*-Gruppe zwar noch gross zu nennen ist, aber durch die Grösse doch nicht mehr auffällt, und der Halsschild ist zum Teil etwas weniger schlank als bei diesem. Die Discoidaleindrücke sind bei einem Teil der Stücke verflacht. Fundort: PHILIPPINEN (*O. Schütze*); ein Stück, PHILIPPINEN, Papatahan (*O. Schütze*).

Das Weibchen von *Callirrhipis helleri* unterscheidet sich, wenn ich die betreffenden beiden Stücke von Mt. Maquiling (*Baker*), Mus. Dresden bezw. N. O. Luzon, Mus. Stettin, die mir unverhältnismässig klein erscheinen (16.4 bez. 15.0 mm), richtig bestimmt habe, vom Männchen ausser durch die allgemeinen Merkmale der Weibchens durch nicht vorgezogenen, in der Mitte breit bogenförmig ausgeschnittenen Vorderteil der Stirn. Der Ovipositor its der der *trepida*-Gruppe. Vom Weibchen der *C. antiqua* Waterhouse weicht es durch viel feinere und viel weniger dichte Punktierung von Halsschild und Flügeldecken sowie kürzere Fühlerlamellen ab. Die feine Punktierung trennt die beiden Stücke auch von allen anderen mir bekannten Weibchen der *trepida*-Gruppe ausser *robusta, formosana, javanica* und *nigrescens.* Von diesen sind sie wieder durch dichtere und etwas kräftigere Halsschild- oder doch (*formosana*) Flügeldeckenpunktierung zu unterscheiden.

CALLIRRHIPIS HELLERI MERIDIONALIS subsp. nov.

Zwei Männchen, MINDANAO, Surigao (*Baker, 16119*); 1 Männchen, SAMAR (*Baker, 22702*). Kleiner (14.4 bis 15.4 mm) als die Stammform (17 bis 19 mm), ihr sehr ähnlich, der Halsschild etwas stärker quer, anderthalbmal so lang wie breit (bei der Stammform ein und ein Drittel bis anderthalbmal) die Discoidaleindrücke gegen die Hintereckeneindrücke etwas deutlicher geschieden. Fühler reichlich drei Vierteln (Mindanao) bis fast neun Zehnteln (Samar) so lang wie der Körper, schon das 5. bis 6. Glied deutlich länger als breit, bei der Stammform erst das 8. bis 9. Rippen der Flügeldecken etwas deutlicher erhaben, besonders hinter der Vereinigung der beiden ersten,

wo die Fläche der Flügeldecken innerhalb der Verlängerung der Rippen bei *meridionalis* einen flachen, doch deutlichen Längseindruck aufweist, die Punktreihen entlang den Rippen kräftiger und dichter als die Hauptpunktierung der Zwischenräume. Die Rundung der Flügeldeckenseiten zur Spiter erfolgt weniger allmählich, wodurch die Rosse etwas robuster erscheint. Länge 14.4 bis 15.4 mm, Schulterbreite 4.2 bis 4.4, Fühlerlänge 11.2 bis 13.4.

CALLIRRHIPIS ANTIQUA Waterhouse (1877).

Callirrhipis viracensis SCHULTZE (1918).

Männchen (*Typus von viracensis*).—CATANDUANES, Virac (*Schultze*). Gehört zu der schwierigen *trepida*-Gruppe; mit grober Hauptpunktierung der Flügeldecken. Da Waterhouse ausdrücklich erwähnt, dass der Halsschild allmählich nach vorn verengt sei, wenn auch nicht viel, und dass die Halsschildeindrücke nicht tief sind, was gerade an dem Typus von *viracensis* auffällt, so muss man wohl *antiqua* Waterhouse (*nec* Schultze, 1915) und *viracensis* als synonym ansehen, wenn es auch nicht unmöglich ist, dass *viracensis* nach Bekanntwerden weitern Materiales als Lokalform (natio) wieder aufleben kann. Denn die mir von den verschiedenen Philippinen-Inseln vorliegenden Einzelstücke weisen sämtlich gewisse Unterschiede voneinander auf. Auch die von Luzon vorliegenden Stücke sind—abgesehen von den bekanntlich sehr bedeutenden Geschlechtsunterschieden—nicht völlig übereinstimmend, insbesondere weist dass Männchen des Stettiner Museums im Gegensatz zu den anderen *antiqua*-Exemplaren einen kräftigen Seitenrandeindruck auf. Dieses Männchen von N. O. Luzon und der Schultzesche Typus weichen von den übrigen durch mehr parabolische Halsschildform und wenig feine, wenig dichte Halsschildpunktierung ab. Demgegenüber besitzt ein Männchen von N. W. Panay (*Baker*) etwas längeren, nach vorn viel breiteren Halsschild mit etwas feinerer und etwas dichterer Punktierung sowie etwas feinere Hauptpunktierung der Flügeldecken. Ein Männchen von Mindanao, Iligan (*Baker*), weist eine wesentlich gröbere und dichtere Halsschildpunktierung und Flügeldecken-Hauptpunktierung auf, während ein Männchen von Negros, Cuernos Mts. (*Baker, 20659*), auf dem ähnlich gestalteten Halsschild etwas gröber, auf den Flügeldecken etwas feiner punktiert erscheint als das von Panay. Die Fühler erscheinen bei den Tieren der mittleren Philippinen eine Kleinigkeit länger. In der Körperform sind die von Panay bis Mindanao robuster und grösser als die der Nordphilippinen. Jedoch schliesst sich ein Männchen

von Polillo (Samml. W. Schultze) in Körperform, Grösse und Punktierung ganz eng an das von Panay an. Ich halte es demgemäss für unrätlich, nach dem mir augenblicklich bekannten Material Lokalformen abzugrenzen und zu benennen.

CALLIRRHIPIS TIAONGONA Schultze (1915).

Männchen (*Typus*).—LUZON, Tayabas, Samml. Schultze. Sehr nahe mit *C. lineata* Waterhouse (1877) verwandt, wie W. Schultze in seiner Beschreibung schon hervorhob. Die Art unterscheidet sich von *lineata* dadurch, dass die Behaarung und deshalb naturgemäss auch die Grundpunktierung auch ausserhalb der Rippen stark entwickelt ist, während beides sich bei *lineata* fast ausschliesslich auf den Rippen verdichtet hat. Nur der Schildchenstreif und manchmal die Basis der 1. Rippe ist auch bei *tiaongona* dichter behaart. Es kann also *lineata* von *tiaongona*, nicht umgekehrt abgeleitet werden. Fürs weibliche Geschlecht, das von *tiaongona* noch unbekannt ist, gelten diese Unterschiede natürlich nicht. Beim Männchen von *scutellata* Fairmaire (1887) fehlt die Grundpunktierung und Behaarung bis auf vereinzelte Spuren auf den Flügeldecken völlig. *Callirrhipis tiaongona* kenne ich noch von Luzon, Mt. Maquiling (*Baker*), Mindanao, Butuan (*Baker*), Salawati (Mus. Berlin), und Batjan (Mus. Kopenhagan). Die beiden Molukkenstücke weichen nur unbedeutend, vor allem durch etwas kräftigere Punktierung, ab.

CHIRONOMIDÆ FROM JAPAN (DIPTERA)
II. MARINE TANYTARSUS [1]

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TWO PLATES

The chironomid flies discussed in the present report were taken entirely at Seto, Wakayama Prefecture, near the Marine Biological Station of the Kyoto Imperial University in the survey of the seashore and marine insects. This important series has added materially to our knowledge of the marine Chironomidæ. Only two species of marine *Tanytarsus* have been described, so far as I know. These are *T. maritimus* Edwards and *T. halophilæ* Edwards, which were collected by Dr. P. A. Buxton from a lagoon in the Samoan Islands. I am greatly indebted to Prof. Dr. Hachiro Yuasa for his kind help and for reading the manuscript of this report.

The abbreviations used in the text are taken mainly from those of F. W. Edwards.[2] A. R. is the ratio of length between the ultimate joint and the remaining joints of the antenna excepting the scape taken together. L. R. is the ratio of length between the basitarsus and the femur of the foreleg. Concerning the hypopygium, the appendage 1 is dorsal; appendage 1_a, supplementary; appendage 2, intermediate; 2_a, ventral, according to Goetghebuer;[3] and 1_b, accessory appendage between 1 and 1_a. Venational terminology used is that of the Comstock-Needham-Tillyard system, which differs from that of Edwards in the following points: M, Cu_1, and Cu_2 of the latter apply to M_{1+2}, M_{3+4}, and Cu_1 of the former, respectively; and fCu of Edwards means the fork between Cu_1 and Cu_2, while that in the text refers to the fork between M_{3+4} and Cu_1.

[1] Contribution from the entomological laboratory of the Kyoto Imperial University, No. 29.

[2] British non-biting midges (Diptera, Chironomidae), Trans. Ent. Soc. London (1929) 279–430.

[3] Chiromariae, Faune de France 18 (1928) 1–171.

Key to the marine species of Tanytarsus.

MALES

1. Wings without macrotrichiæ on the membranous area. *T. pontophilus* sp. nov.
   Wings with macrotrichiæ on the membranous area .... 2.
2. Cell M_4 without macrotrichiæ .... 3.
   Cell M_4 with macrotrichiæ .... 4.
3. Hypopygium with 1_b; fCu located just below the basal section of Rs. *T. boodleæ* sp. nov.
   Hypopygium without 1_b; fCu located far beyond the basal section of Rs. *T. maritimus* Edwards.
4. Anal point of the ultimate tergite chitinized and pointed. *T. pelagicus* sp. nov.
   Anal point of the ultimate tergite membranous and blunt .... 5.
5. Distal joint of the antenna much longer than the preceding three joints taken together .... *T. magnihamatus* sp. nov.
   Distal joint of the antenna subequal in length to the preceding three joints taken together .... *T. halophilæ* Edwards.

FEMALES

1. Cerci elongated and pointed .... 2.
   Cerci short and of various forms .... 5.
2. Wings very scantily haired and cell M_4 bare .... *T. pontophilus* sp. nov.
   Wings moderately haired and cell M_4 hairy .... 3.
3. fCu located just below the basal section of Rs. *T. magnihamatus* sp. nov.
   fCu located far beyond the basal section of Rs .... 4.
4. Joints 3 and 4 of antenna without distinct necks. *T. halophilæ* Edwards.
   Joints 3 and 4 of antenna with necks, slender at each end. *T. maritimus* Edwards.
5. Antenna 5-segmented .... *T. boodleæ* sp. nov.
   Antenna 6-segmented .... *T. pelagicus* sp. nov.

TANYTARSUS BOODLEÆ sp. nov.

This species lives in association with *Pontomyea pacifica* Tokunaga between the tide marks in the shallow tide pool the bottom of which is thickly covered with the alga *Boodlea coactata*.

The imagines swarm actively on the edge of the tide pool at night and are most active about two hours after sunset. The larvæ and pupæ nest among the algal filaments, using the débris of algæ.

Male.—Body 1.9 to 2 millimeters in length; thorax brown with deep brown dorsal stripes; abdomen yellowish white.

Eyes bare, comparatively broad, reniform, not widely separated from each other; distance between them on the dorsal side about half as great as the vertical length of the eye. Antennæ 14-segmented; distal joint very short, shorter than the preceding three

joints taken together and sometimes reduced to about twice as long as the preceding one joint, with two small setæ at its tip; A. R. about 0.2 (8 : 36). Maxillary palpi distinctly 4-segmented (37 : 25 : 18 : 6). Clypeus setigerous with long setæ.

Pronotum vestigial, not visible from above; præscutum produced forwards over the head, provided with three longitudinal rows of erect setæ between the dorsal stripes; supra-alar setal group represented by a variable number of setæ (2 to 4); scutellum pale brown, provided with six large and two small setæ.

Hypopygium (Plate 1, fig. 7) generally yellowish white; ultimate tergite scantily haired with small setæ; anal point completely atrophied; coxites very broad, each with three stiff setæ on the ventromesal margin; appendage 1 swollen dorsad, bearing two small setæ on the mesal part and a tuberculated patch consisting of three minute setæ on the proximal part, pointed mesad, with one or two small setæ on its tip; 1_a with a terminal knob on which three minute setæ are found; 1_b located between the above two appendages, fingerlike, pointed, quite smooth; 2 extended at the middle of the style, setæ on its tip not curved distinctly, small setæ along its dorsomesal ridge extended cephalad; 2_a small, slender, bearing many minute, branched setæ on its tip.

Legs pale yellow; forelegs each with a fixed tibial spine; L. R. about 1.57; middle and hind legs provided with two combs on each leg; combs occupying about two-thirds of the circumference of the tibia, widely separated from each other; one comb with a long spur which is nearly thrice as long as the comb itself, the other with a much shorter spur, being almost twice as long as the comb; claws slender, unserrated; empodium slender; pulvilli slightly shorter than the claw and subequal in length to the empodium, covered entirely with minute hairs.

Wings (Plate 1, fig. 1) hyaline under transmitted light, without markings, scantily haired on the cells R_5 and M_2; anal angle fairly developed; squama quite bare; R_{4+5} ending slightly beyond the level of the tip of M_{3+4}, twice as long as R_1, slightly curved along the costal margin; r-m twice as long as the basal section of Rs; fCu narrow, located just below the basal section of Rs; M_{3+4} a slightly bent caudad at its tip; Cu_1 almost straight; 1A slightly curved caudad, scarcely reaching the base of fCu.

Female.—Body slightly longer than in the male, 1.9 to 2.2 millimeters in length. Thorax pale brown, with brown dorsal stripes, scutellum pale brown; other parts of the body generally whitish. Eyes far broader than in the male. Antennæ 5-seg-

mented (23 : 10 : 10 : 22 : 12); second proximal joint deeply constricted at middle; distal joint slightly longer than the preceding two joints taken together, with two or three apical setæ. Wings (Plate 1, fig. 2) densely haired and broad; fCu located slightly beyond the basal section of Rs. Hypopygium (Plate 2, fig. 13) setigerous with small setæ; ultimate sternite subrectangular, its caudal incision angulated in U-shape and its infolded mesocaudal thickening deeply U-shaped; cerci broad, subtriangular, extended caudad; two spermatothecæ, spheroid and hyaline. Other structures of the head, thorax, legs, and wings as in the male.

Habitat.—*Boodlea* tide-pool, between tide marks, Japan.

Holotype.—Male; Seto, Wakayama Prefecture; August 29, 1931.

Allotopotype.—Female; August 29, 1931.

Paratopotypes.—Males and females; August 30 and 31, 1930, and August 10 to 31, 1931.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University and the British Museum; collected by M. Tokunaga.

This species is related to *T. maritimus* Edwards, but distinctly differs in the position of fCu, which is located just below the basal section of Rs, the presence of the hypopygial appendage 1_b of the male, and the short subtriangular cerci of the female. In the related species fCu is located far beyond the basal section of Rs, the appendage 1_b is wanting, and the cerci are long and pointed.

TANYTARSUS PONTOPHILUS sp. nov.

The adults of this species swarm very close to the water in the concavities of rocks which are formed by the wave action and which become submerged at full tide. The flies brave the sprays of water and take care of themselves agilely against the breaking waves. The immature forms are found on the algal matting of the flat rocky shore below the high-tide mark.

Male.—Body 1.7 to 1.8 millimeters and wing 1.2 to 1.3 millimeters in length. Thorax brown, with dark brown dorsal stripes. Abdomen yellowish, the tip slightly brown.

Eyes bare, reniform, widely separated from each other; distance between them being greater than the vertical length of the eye (23 : 17). Antennæ 14-segmented; scape dark brown, without sensory pores and setæ; A. R. about 0.4 (34 : 81); distal joint as long as the preceding four joints taken together, with two apical setæ. Maxillary palpi with four distinct joints

(34 : 18 : 13 : 5); distal joint slightly longer than the preceding two joints taken together. Clypeus with about fifteen long setæ. Frontal tubercles obsolete.

Pronotum reduced, not visible from above, without setæ. Præscutum produced forwards over the head, provided with three longitudinal rows of about twelve to fourteen small erect setæ. Supra-alar setal group always with three setæ. Scutellum pale brown, with two long median and four short lateral setæ.

Hypopygium (Plate 1, fig. 8) provided with the ordinary number of appendages. Anal point not thickened, being represented only by a membranous projection which is provided with two short apical setæ. Styles straightly extended caudad, suddenly narrowed at the tip; coxites large, each provided with four short but stiff setæ on the ventromesal margin. Appendage 1 subrectangular from above, provided with several minute setæ on its dorsal side; 1_a pointed, quite bare, slightly longer than appendage 1; appendage 2 extended at the middle of the style, not distinctly broad, almost straight, crowned with short curved setæ, with a few small setæ on the ventromesal edge of the stem; appendage 2_a slender, provided with a tuft of simple hairs on the distal part.

Legs pale brownish yellow; forelegs each with a fixed tibial spine, which is almost half as long as the diameter of the tibia itself; middle and hind tibiæ each with two combs; combs widely separated from each other, occupying about one-third of the circumference of the tibia, provided with unequal spurs, one on each comb; the longer one nearly twice as long as the comb itself, the other slightly longer than the comb; L. R. about 1.5. Claws slender, unserrated; empodium slender and slightly shorter than the claw; pulvilli distinct, subequal in length to the empodium, covered with minute slender hairs.

Wings (Plate 1, fig. 3) hyaline under transmitted light, without any markings; macrotrichiæ completely wanting on the membranous area; anal angle atrophied; squama bare. Vein R_{4+5} almost straight, ending on the level as the tip of M_{3+4}, about twice as long as R_1; r-m very short and subequal to the basal section of Rs; base of fCu located below the base of Rs; 1A nearly straight, beyond the base of fCu being atrophied before the wing margin.

Female.—Body subequal to or slightly shorter than that of the male; wings broader than but subsequal in length to those of the

male. General appearance far paler than in the male. Eyes similar to those of the male in shape, distance between them greater than in the male and very slightly more than the vertical length of the eye (10 : 9). Maxillary palpi 4-segmented (33 : 21 : 13 : 15); distal joint subequal in length to the preceding two joints taken together. Antennæ 5-segmented; distal joint elongated, with a small apical seta, slightly longer than the preceding two joints taken together (27 : 11 + 11); each of the proximal three fusiform joints of the flagellum with five long setæ and two trichoid sensory organs; second proximal joint shallowly constricted at middle. Wings (Plate 1, fig. 4) scantily haired only on the distal parts of cells R_5, M_2, and along a longitudinal line on cell R_5; r-m twice as long as the basal section of Rs, R_{4+5} slightly curved along the costal margin. Hypopygium (Plate 2, fig. 14) covered with minute setæ and without long setæ excepting several long setæ on the ultimate sternite; ultimate sternite elongated, subpentagonal in shape and pointed at the tip, with three pairs of strong setæ on the caudal margin; caudal incision represented only by a shallow U-shaped ental thickening; cerci long, not pointed sharply, five times as long as wide, conspicuously extended caudad far beyond the caudal tip of the ultimate tergite; spermatothecæ two, quite spherical and hyaline. Other characters of the head, thorax, legs, and wings as in the male.

Habitat.—Rocky flat seashore between the tide marks, Japan.

Holotype.—Male; Seto, Wakayama Prefecture; June 30, 1930.

Allotopotype.—Female; June 30, 1930.

Paratopotypes.—Males and females; August 13 and 30, 1930.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University and the British Museum; collected by M. Tokunaga.

This species is allied to *T. maritimus* Edwards, but distinguishable by the following structures: The ultimate joint of the male antenna longer than the preceding three joints taken together, L. R. about 1.5, wings of the male without macrotrichiæ on the membranous area, and fCu of the wing located just below the basal section of Rs.

TANYTARSUS MAGNIHAMATUS sp. nov.

This fly is found swarming low over the flat rocky shore, thinly covered with the algal matting and sand, of calm bays at ebb tide. Many females were also collected by a light trap ashore.

Male.—Body about 2.1 millimeters in length; uniformly yellowish white and sometimes with slightly brownish dorsal stripes.

Eyes bare, fairly broad, reniform, distinctly separated from each other; distance between them on the dorsal side being subequal to or very slightly narrower than the vertical length of the eye. Antennæ 14-segmented; distal joint provided with three short apical setæ, as long as the preceding five or six joints taken together; A. R. about 0.5. Maxillary palpi with four distinct joints (38 : 28 : 23 : 8), distal joint shorter than the preceding two joints taken together. Pronotum reduced; præscutum produced forwards over the head; supra-alar setal group provided with three setæ; scutellum provided with six large median and two short lateral setæ.

Hypopygium (Plate 1, fig. 9) distinctly broad laterad; ultimate tergite also broad laterad and narrow longitudinally, without a thickened anal point but with a smooth, blunt, membranous, anal projection, scantily covered with short setæ on the meson; coxites broad dorsoventrad, extending caudodorsad; styles also broad dorsoventrad, extending caudad, with strong but short setæ on the dorsal margin; appendage 1 very small, not projected mesad, its dorsal side setigerous with many short setæ; 1_a fingerlike, with three minute setæ on its distal knob: 1_b located over 1_a or distad of 1, quite smooth, membranous, varying in size in different individuals; 2 distinctly broad dorsoventrad, crowned with conspicuous recurved setæ; 2_a very large, extended nearly as far caudad as 2, setigerous with fine slender hairs over most of its surface excepting only on its base.

L. R. about 1.5; foreleg with one distinct fixed tibial spine which is as long as the diameter of the tibia itself; middle and hind legs each with two tibial combs; combs occupying about two-thirds of the circumference of the tibia, distinctly separated from each other, with one spur on each comb; two spurs on one leg unequal in length to each other; longer one is nearly thrice and the other twice and half as long as the comb itself. Claws simple, empodium slender, setigerous, with very minute hairs, slightly shorter than the claw; pulvilli distinct, subequal in length to the empodium, broad distad, with many long hairs on the distal part.

Wings (Plate 1, fig. 5) about 0.9 to 1 millimeter in length, hyaline under transmitted light, without markings, distinctly haired with short macrotrichiæ over most of the membranous area; anal

angle fairly developed; squama bare. Vein R_{4+5} twice as long as R_1, curved along the costal margin, ended slightly beyond the level of the tip of M_{3+4}; fCu located just below r-m; r-m subequal in length to the basal section of Rs; 1A almost straight, not beyond the base of fCu.

Female.—Body about 1.9 millimeters in length. Antennæ 5-segmented (31 : 14 : 14 : 24 : 13); distal joint of the flagellum slightly longer than the preceding two joints taken together, with two small apical setæ; proximal second joint constricted distinctly at middle. Wings (Plate 1, fig. 6) larger, comparatively broader and more densely haired than those of the male, measuring about 1.6 to 1.7 millimeters in length. Cerci (Plate 2, fig. 15) extended caudad, elongated, somewhat rhombic in shape, about two and one-half times as long as width of the proximal part, covered with small setæ on the entire surface; ultimate tergite bluntly projected caudad, also covered with small setæ; ultimate sternite subrectangular in shape, truncated at its distal margin, somewhat narrow caudad, bearing on the caudal margin about eight long setæ which are extended as far as the tip of the cerci, scantily haired on its distal half, its caudal incision incomplete and represented by a U-shaped ental thickening. Other structures of the head, thorax, legs, and wings as in the male.

Habitat.—Rocky flat seashore on the tidal zone, Japan.

Holotype.—Male; Seto, Wakayama Prefecture; June 24, 1930.

Allotopotype.—Female; June 24, 1930.

Paratopotypes.—Males; June 24, 1930.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University and the British Museum; collected by M. Tokunaga.

This species is easily distinguishable from the allied species by the exceedingly large appendage 2_a of the male. It is somewhat related to *T. halophilæ* Edwards but differs in the possession of the characteristic hypopygial appendages 1, 1_a, and 1_b of the male and the long terminal joint of the antenna of the male.

TANYTARSUS PELAGICUS sp. nov.

This fly was collected from the same habitat as *T. pontophilus.*

Male.—Body about 1.8 to 1.9 millimeters and wings about 1.2 millimeters in length; thorax brown, with dark brown dorsal stripes; abdomen and legs yellowish; hypopygium slightly brown; general impression setigerous.

Eyes bare, reniform, not widely separated from each other, distance between them on the dorsal side being slightly less than

the vertical length of the eye (50 : 75). Antennæ 14-segmented; scape dark brown; distal joint with an apical seta, as long as the preceding five joints taken together; A. R. about 0.4 (13 : 30). Maxillary palpi distinctly 4-segmented (34 : 23 : 23 : 7); distal joint far shorter than the preceding two joints taken together. Clypeus provided with many long setæ.

Pronotum reduced, not visible from the dorsal aspect. Præscutum produced forwards over the head, provided with several erect setæ on its cephalic part besides the three longitudinal rows of setæ; supra-alar setal group represented always by a single seta. Scutellum pale brown, provided with two long median and four short lateral setæ.

Abdomen slender with many long setæ. Hypopygium (Plate 2, fig. 12) also provided with many long setæ and slightly brown in color; ultimate tergite provided with thickened anal point, large V-shaped thickening and scantily setigerous with long setæ between the V-shaped thickening; coxites broad, setigerous with very long setæ and each with three stiff setæ on the thickened ventromesal margin; styles also setigerous, extended caudodorsad, being slightly bent caudad at its tip; appendage 1 broad, subtriangular, with about five short setæ, extended mesad at its tip; 1_a quite smooth, clawlike, slightly extended mesad beyond 1; 2 comparatively broad, crowned with many short curved setæ only at its tip, extending caudad at the middle of the style; 2_a long slender, extending caudad as far as the tip of the coxite, provided with long, soft, simple hairs on its entire surface.

Foreleg provided with a simple fixed tibial spine; posterior four legs each with two tibial combs which occupy about two-thirds of the circumference of the tibia; each comb with a single accessory spur which is not longer than twice the comb itself; L. R. about 1.3 (4 : 3); pulvilli setigerous with short hairs, slightly shorter than the claw; empodium slender, subequal in length to the pulvilli.

Wings (Plate 2, fig. 10) hyaline under transmitted light, without markings, scantily haired with small macrotrichiæ on the distal region of the cells R_5, M_2, and M_4 and on the veins R, Cu, and 1A, and the wing margin; anal angle almost atrophied; squama bare. Vein R_{4+5} ending on the level of the tip of M_{3+4}, slightly curved along the costal margin, about twice as long as R_1 (43 : 23); basal section of Rs slightly shorter than r-m; fCu narrow, located just below the basal section of Rs; M_{3+4} and Cu_1 almost straight; 1A reaching the base of fCu.

Female.—Body far shorter than that of the male, about 1.5 to 1.7 millimeters in length; general appearance far paler than in the male; dorsal stripes of the præscutum and the postscutellum slightly brown in color. Antennæ 6-segmented (10 : 10 : 10 : 10 : 16 : 9) ; scape very small; distal four joints subequal in shape and size to each other; distal joint with only one short apical seta; proximal second joint very slightly constricted at middle. Maxillary palpi segmented, with four distinct joints (32 : 21 : 16 : 5) ; distal joint slightly shorter than the preceding two joints taken together; second joint slightly shorter than the third (in the male they are subequal in length to each other). Wings (Plate 2, fig. 11) about 1.1 millimeters in length, comparatively broad, densely covered with macrotrichiæ. Hypopygium (Plate 2, fig. 16) covered with long setæ; ultimate sternite broad, its caudal incision large but shallow, V-shaped and its caudomesal thickening large and U-shaped; cerci small, not extended caudad but distinctly elongated cephalad and slightly folded mesad at the ventral margin; spermatothecæ small, spheroid, two in number. L. R. 1.2 to 1.3. Other structures of the head, thorax, legs, and wings closely similar to those of the male.

Habitat.—Rocky flat seashore under the high tide mark, Japan.

Holotype.— Male; Seto, Wakayama Prefecture; June 17, 1930.

Allotopotype.—Female; June 17, 1930.

Paratopotypes.—Males; June 17, 1930.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University and the British Museum; collected by M. Tokunaga.

Both sexes of this species resemble *T. magnihamatus* but identifiable distinctly by the structures of the hypopygium: anal point of the ultimate tergite of the male thickened and pointed and caudal incision of the ultimate sternite of the female wanting, while in the allied species the anal point is reduced and the caudal incision is present.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Tanytarsus boodleæ* sp. nov., male, wing.
2. *Tanytarsus boodleæ* sp. nov., female, wing.
3. *Tanytarsus pontophilus* sp. nov., male, wing.
4. *Tanytarsus pontophilus* sp. nov., female, wing.
5. *Tanytarsus magnihamatus* sp. nov., male, wing.
6. *Tanytarsus magnihamatus* sp. nov., female, wing.
7. *Tanytarsus boodleæ* sp. nov., male hypopygium, dorsal aspect, with appendage 2a.
8. *Tanytarsus pontophilus* sp. nov., male hypopygium, dorsal aspect, with appendage 2a.
9. *Tanytarsus magnihamatus* sp. nov., male hypopygium, dorsal aspect.

PLATE 2

FIG. 10. *Tanytarsus pelagicus* sp. nov., male, wing.
11. *Tanytarsus pelagicus* sp. nov., female, wing.
12. *Tanytarsus pelagicus* sp. nov., male hypopygium, dorsal aspect, with appendage 2a.
13. *Tanytarsus boodleæ* sp. nov., female, ultimate sternite, ventral aspect, and cercus, lateral aspect.
14. *Tanytarsus pontophilus* sp. nov., female, ultimate sternite, ventral aspect, and cercus, lateral aspect.
15. *Tanytarsus magnihamatus* sp. nov., female, ultimate sternite, ventral aspect, and cercus, lateral aspect.
16. *Tanytarsus pelagicus* sp. nov., female, ultimate sternite, ventral aspect, and cercus, lateral aspect.

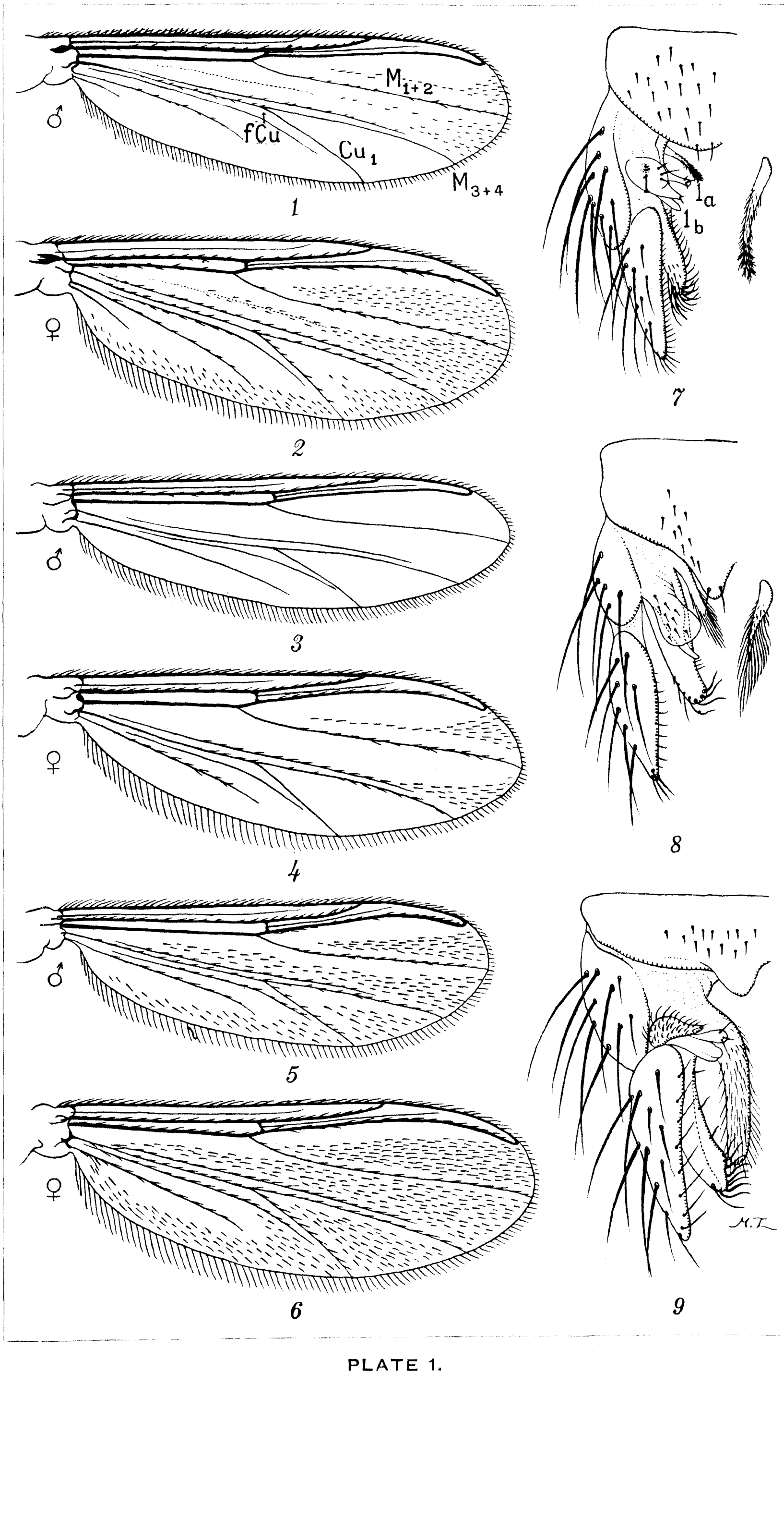

PLATE 1.

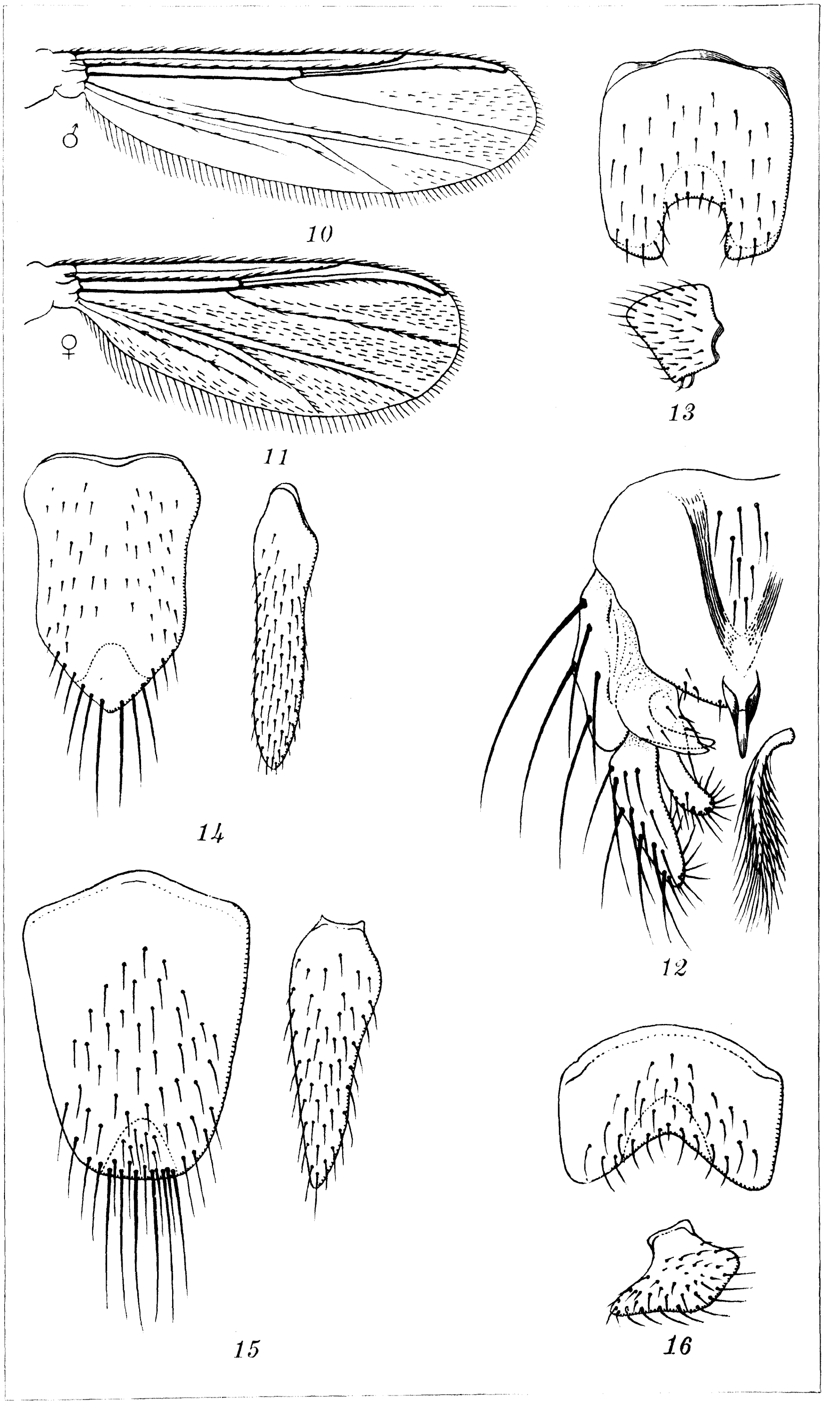

PLATE 2.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XIII[1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

FOUR PLATES

The crane flies discussed at this time are chiefly from Japan, where they were collected by my friends Messrs. Esaki, Hibi, Imanishi, Inomata, Issiki, Machida, Nakamura, Oda, Sakaguchi, Shiraki, Takahashi, and Tokunaga. The smaller but highly important series from China were taken on Mount Omei, Szechwan, by the Reverend Mr. Franck. I wish to express my deepest thanks to all of the gentlemen above mentioned for this continued interest in developing our knowledge of the Tipulidæ of the Eastern Palæarctic region. The types of the novelties are preserved in my collection.

In accordance with a policy adopted in earlier parts under this general title, detailed lists of the Tipulidæ of certain mountainous areas in Honshiu, Japan, are here supplied. It is only by means of such lists that our knowledge of distribution of the Japanese crane flies can make material progress.

Mount Shirouma (Mount Hakuba, or White Horse Mountain), in the alpine country between the Provinces of Echiu, Echigo, and Shinano, August 8, 1931 (J. Machida and T. Nakamura).

Dolichopeza (Nesopeza) geniculata (Alex.).
Tipula (Schummelia) bidenticulata sp. nov.
Tipula (Acutipula) bubo Alex.
Tipula depressa Alex.
Tipula nigrosignata Alex.
Tipula verecunda Alex.
Cylindrotoma japonica Alex.
Limonia (Limonia) euphileta Alex.
Limonia (Limonia) fusciceps Alex.
Limonia (Limonia) karafutonis Alex.
Limonia (Limonia) neoindigena Alex.
Limonia (Limonia) pullata Alex.
Limonia (Limonia) subnubeculosa Alex.

[1] Contribution from the entomological laboratory, Massachusetts State College.

Limonia (*Limonia*) *tanakai* Alex.
Limonia (*Dicranomyia*) *immodestoides* (Alex.).
Pedicia (*Pedicia*) *brachycera* Alex.
Pedicia (*Pedicia*) *subtransversa* Alex.
Dicranota (*Dicranota*) *nippoalpina* Alex.
Epiphragma (*Epiphragma*) *subfascipennis* Alex.
Limnophila (*Tricholimnophila*) *brevirama* Alex.
Limnophila subnemoralis Alex.
Erioptera (*Erioptera*) *juvenilis* Alex.
Ormosia machidana sp. nov.
Ormosia nantaisana Alex.
Molophilus nakamurana sp. nov.

Mount Kiyozumi, Bōsō Peninsula, Kāzusa, altitude 380 meters, May 5, 1931 (Bunkichi Oda).

Dolichopeza (*Nesopeza*) *tarsalis* (Alex.).
Tipula (*Nippotipula*) *coquilletti* End.
Tipula (*Schummelia*) *ecaudata* Alex.
Limonia (*Limonia*) *anthracina* Alex.
Limonia (*Limonia*) *euphileta* Alex.
Limonia (*Limonia*) *japonica* Alex.
Dicranota (*Rhaphidolabis*) *consors* Alex.
Limnophila (*Prionolabis*) *odai* sp. nov.
Limnophila (*Tricholimnophila*) *flavella* Alex.
Molophilus trifilatus Alex.

Mount Mitake, Musashi, altitude to 700 meters, May 10, 1931 (Bunkichi Oda).

Cylindrotoma japonica Alex.
Triogma kuwanai (Alex.).
Phalacrocera mikado Alex.
Limonia (*Limonia*) *euphileta* Alex.
Limonia (*Dicranomyia*) *pseudomorio* (Alex.).
Limonia (*Geranomyia*) *multipuncta* (Alex.).
Pedicia (*Tricyphona*) *optabilis* (Alex.).
Ula succincta sp. nov.
Limnophila (*Tricholimnophila*) *pilifer* Alex.
Ormosia confluenta Alex.

TIPULINÆ

DOLICHOPEZA (OROPEZA) INOMATAI sp. nov. Plate 1, fig. 1; Plate 2, fig. 25.

General coloration of mesonotum polished cinnamon-brown; legs brown, tarsi paling to obscure yellow; abdomen bicolorous, the bases of segments dark brown, the apices obscure yellow; male hypopygium with the median area of tergite produced into a bispinous or weakly trispinous plate; lateral arms of tergite densely set with microscopic recurved spinulæ; inner dististyle with very long, angularly bent setæ near outer end.

Male.—Length, 9 to 10 millimeters; wing, 9.5 to 11.

Female.—Length, about 11 millimeters; wing, 10.5.

Frontal prolongation of head brown; palpi brownish black. Antennæ with scape and pedicel yellow; flagellum black. Head pale brown, passing to yellowish on frontal portion.

Mesonotal præscutum polished cinnamon-brown, the posterior sclerites somewhat darker. Halteres pale, the knobs darkened. Legs dark brown, the femoral bases and outer tarsal segments more yellowish. Wings (Plate 1, fig. 1) with a pale brownish tinge, the oval stigma darker brown, conspicuous, preceded and followed by cream-colored areas; a pale obliterative streak across cell 1st M_2; veins pale brown.

Abdomen bicolorous, the bases of the segments dark brown, the apices somewhat more broadly obscure yellow; subterminal segments more uniformly darkened; hypopygium obscure yellow. Male hypopygium (Plate 2, fig. 25) with the caudal margin of tergite, *9t,* produced in median portion into two subacute triangular points, one on either side of median line; on ventral surface a smaller median point, so that in certain aspects this tergal plate appears tridentate; lateral arms of tergite expanded, with carinæ, the cephalic face of club with abundant microscopic pale spinulæ that are more or less recurved. Outer dististyle, *od,* relatively short, with long setæ. Inner dististyle, *id,* slender, clothed with conspicuous setæ, those near the base small, those before apex long and angularly bent and thickened at near midlength, the apical setæ again straight and spiniform. Ædeagus, *a,* simple. Gonapophyses appearing as pale setiferous lobes.

Habitat.—Japan (Honshiu).

Holotype, male, Kyusho Mountain, Hôki, June 13, 1930 (*Hibi*). Allotopotype, female. Paratopotypes, 2 males.

This interesting new *Oropeza* is named in honor of my friend Prof. Shujiro Inomata, to whom I am indebted for many interesting Tipulidæ from Tottori. The only described Japanese member of the subgenus that is at all similar to the present fly is *D.* (*O.*) *bispinula* (Alexander), likewise from the mountains of Honshiu. The hypopygium of the latter fly is very different, the outer ends of the lateral tergal arms being very large and smooth, while the setæ of the inner dististyle are short and simple.

MACGREGOROMYIA BREVICULA sp. nov. Plate 1, fig. 2; Plate 2, fig. 26.

General coloration of thorax brownish black; antennæ (male) elongate, exceeding one-half the length of the body; halteres yellow, the knobs black; legs black; wings grayish subhyaline, the

costal region more yellowish; stigma and a narrow seam along cord dark brown; Rs very short, less than the arcuated r-m, the latter connecting with the basal section of R_{4+5}; cell 1st M_2 very small; abdominal segments bicolorous, dark brown basally, the apices broadly yellow.

Male.—Length, about 10 millimeters; wing, 11.5; antenna, about 5.8.

Frontal prolongation of head buffy; palpi black, the terminal segment exceeding in length the remainder of organ. Antennæ (male) relatively long, as shown by measurements; scape and pedicel buffy yellow; flagellum black; flagellar segments long-cylindrical, the basal enlargements very slightly developed, with tiny verticils that are about as long as the diameter of the segment. Head brown; anterior vertex more grayish.

Mesonotum chiefly blackish, the præscutal interspaces paler. Pleura dark-colored, crushed in the unique type. Halteres elongate, yellow, the knobs black. Legs black. Wings (Plate 2, fig. 2) grayish subhyaline, the prearcular and costal regions slightly more yellow; stigma oval, dark brown; a narrow but conspicuous dark seam along cord; still narrower dark borders to veins Cu and 2d A; posterior wing margin extensively but narrowly bordered by brown; veins dark brown, C, Sc, and R more yellowish. Venation: Rs very short, transverse, subequal to basal section of R_{4+5} and much shorter than the arcuated r-m; r-m connecting with R_{4+5} and not directly with Rs, as in the other species of genus; R_{1+2} preserved, parallel to free tip of Sc_2; cell 1st M_2 very small, narrowed outwardly; m-cu just beyond fork of M.

Abdomen with the basal segment dark brown; second tergite chiefly light yellow with a brown transverse ring just beyond midlength; succeeding tergites brown basally, their apices broadly yellow; segments eight and nine uniformly dark brown. Male hypopygium (Plate 2, fig. 26) with the tergite, *9t,* notched medially, as in the genus. Outer dististyle, *od,* a long, slender, pale lobe clothed with conspicuous setæ. Inner dististyle, *id,* with the posterior or "heel" portion prolonged into an obtuse setiferous lobe. Ædeagus, *a,* simple.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 3,500 feet, August 16, 1931 (*Franck*).

Macgregoromyia brevicula differs from the four species of the genus hitherto described in having r-m connecting with vein R_{4+5} rather than with Rs before the fork of the latter. The group certainly appears to belong to the subtribe Dolichopezaria,

in the vicinity of *Dolichopeza* Curtis and *Scamboneura* Osten Sacken.

TIPULA (SCHUMMELIA) BIDENTICULATA sp. nov. Plate 1, fig. 3; Plate 2, fig. 27.

Belongs to the *continuata* group; general coloration yellow, conspicuously variegated with dark brown, including three præscutal stripes; antennal flagellum weakly bicolorous; wings with the ground color strongly infumed, variegated by dark brown and cream-colored areas; male hypopygium with the caudal end of the ninth tergite shallowly emarginate; inner dististyle prolonged behind, terminating in two acute blackened points.

Male.—Length, about 13 millimeters; wing, 14.

Female.—Length, about 12 to 14 millimeters; wing, 14 to 15.

Frontal prolongation of head testaceous-yellow; nasus elongate; palpi black. Antennæ with scape and pedicel light yellow; flagellum weakly bicolorous, brown, the basal enlargement of each segment a little darker than the remainder; antennæ (male) relatively short, if bent backward extending to the wing root or shortly beyond. Head yellow, most evident as a broad median stripe extending the whole length, bordered on either side by dark brown; posterior orbits very narrowly obscure yellow.

Pronotum broadly yellow medially, brown laterally. Mesonotal præscutum with the ground light yellow, with three conspicuous dark brown stripes, the median one feebly split by a capillary reddish line; lateral stripes with anterior ends approaching the median one and the interspaces here suffused with brown, though conspicuously light yellow behind; humeral region of præscutum broadly of the ground color; scutum, scutellum, and mediotergite broadly yellow medially, dark brown laterally, the scutellum more testaceous and with a faintly indicated dark median vitta. Pleura yellow, conspicuously variegated with dark brown on ventral anepisternum, sternopleurite, and meron; posterior sclerites of pleura chiefly yellow. Halteres obscure yellow, the knobs clearer yellow. Legs with the coxæ yellow, slightly darkened at bases; trochanters yellow; femora obscure yellow, the tips narrowly brownish black; tibiæ dark brown, the bases restrictedly pale, the tips narrowly blackened; tarsi black; claws (male) slender, with basal tooth. Wings (Plate 1, fig. 3) with the ground color strongly infumed, variegated by darker brown and cream-colored areas; darker areas chiefly evident as the stigma and as a broad seam on m-cu and distal section of Cu_1; vein 2d A narrowly seamed with brown; the creamy areas appear as a narrow obliterative band along cord; basal half of cell

R_2; areas near outer end of cell M, bases of cells Cu and 1st A, outer end of cell 1st A, adjoining vein 2d A, and along outer end of vein 1st A. Squama naked. Venation: R_{1+2} pale but preserved, without trichia on distal third or more.

Abdominal tergites obscure yellow, the first and base of second clearer yellow; succeeding tergites more obscure, the margins pale; hypopygium with the tergite dark brown, the sternites more brownish yellow. In the female, the incisures are more conspicuously light yellow. Male hypopygium (Plate 2, fig. 27) with the tergite, *9t*, separated from the sternite, *9s;* basistyle entirely fused with sternite. Ninth tergite, *9t*, with the caudal margin very broadly and evenly emarginate, on ventral surface more sclerotized. Outer dististyle, *od*, a pale subcylindrical rod, gradually narrowed to the obtuse apex, clothed with elongate setæ. Inner dististyle, *id*, produced behind into a bispinous point. Eighth sternite, *8s*, unarmed.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Shirouna, Shinano (Japanese Alps), August 8, 1931 (*Machida and Nakamura*). Allotopotype, female. Paratopotype, female.

The Japanese species of *Schummelia* now total more than a dozen and may be arranged in three groups. Of these, the *macrotrichiata* group includes *macrotrichiata* Alexander, *sparsiseta* Alexander, and *sparsissima* Alexander, separated by the presence of macrotrichia in the outer cells of the wing. The *variicornis* group includes *acifera* Alexander, *insulicola* Alexander, *insulicola fuscicauda* Alexander, *variicornis* Schummel, var., and presumably *nikkoensis* Alexander, still known only from the female sex. The remaining species fall in the *continuata* group, with *ecaudata* Alexander, *imanishii* sp. nov., *jocosipennis* sp. nov., *nipponensis* Alexander, *querula* Alexander, and the present species. *Tipula bidenticulata* is closest to *nipponensis* in the caudal extension of the inner dististyle of the male hypopygium, but the conformation of the styli is quite distinct.

TIPULA (SCHUMMELIA) JOCOSIPENNIS sp. nov. Plate 1, fig. 4; Plate 2, fig. 28.

Belongs to the *continuata* group; antennal flagellum black; mesonotum gray, the præscutum with three darker gray stripes; thoracic pleura variegated with yellow and brownish gray; wings with the ground color whitish, the prearcular and costal regions light yellow, the disk heavily patterned with brown, most conspicuously on the wing tip and along veins m-cu and distal section of Cu_1; male hypopygium with the inner dististyle mitten-

shaped, the cephalic edge at near midlength produced into a blackened point.

Male.—Length, about 10 to 11 millimeters; wing, 13 to 14.

Female.—Length, about 13 to 14 millimeters; wing, 14 to 15.

Frontal prolongation of head chiefly buffy yellow; palpi pale yellow, the outer segment passing into brown. Antennæ with the scape and pedicel light yellow; flagellum black; antennæ (male) relatively long, if bent backward extending about to root of halteres. Head with front and anterior vertex pale yellow, the remainder of vertex brownish gray. Mesonotum gray, with three darker gray stripes, the lateral pair somewhat darker, the median stripe more or less split on posterior portion; scutal lobes darkened; scutellum pale brown, with a more blackish median vitta; mediotergite dark plumbeous gray. Pleura yellow, variegated with brownish gray on anepisternum, sternopleurite, and meron. Halteres chiefly pale yellow. Legs with the coxæ and trochanters yellow; remainder of legs broken. Wings (Plate 1, fig. 4) with the ground color whitish, the prearcular and costal regions light yellow; stigma dark brown, very conspicuous; paler brown areas on disk, the most distinct being the wing tip and broad seams on m-cu and distal section of Cu_1; less evident washes on anterior cord, in outer end of cell 1st A, and as a marginal seam at end of vein 2d A; cells R and M vaguely suffused with pale brown, leaving an extensive ground area before outer end of latter; obliterative areas involving end of Rs, basal sections of M_{1+2} and M_3; veins brown, paler in the obliterative areas, more yellowish in the flavous costal portion. Venation: As in the subgenus; Rs a little longer than m-cu, the latter connecting with M_{3+4} shortly before its fork.

Abdominal tergites yellow, with a nearly continuous brownish black to dark brown median stripe, narrowly interrupted at the caudal margins of the intermediate segments; segments seven to nine, inclusive, more uniformly blackened; sternites chiefly yellow, the seventh and eighth segments blackened. Male hypopygium (Plate 2, fig. 28) with the tergite, *9t*, entirely distinct from the sternite-basistyle, *9s–b*, the two latter entirely fused. Median region of sternite broadly membranous. Ninth tergite, *9t*, black, the caudal margin with a broadly rounded emargination, the lateral lobes obtuse. Outer dististyle, *od*, pale, elongate-cylindrical. Inner dististyle, *id*, mitten-shaped, the cephalic edge at near midlength produced into a blackened point.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Ohdai, Yamato, altitude 2,600 feet, June 5, 1930 (*Sakaguchi*). Allotopotype, female. Paratopotypes, 3 of both sexes.

Tipula (*Schummelia*) *jocosipennis* differs from *T.* (*S.*) *ecaudata* Alexander and *T.* (*S.*) *querula* Alexander, which appear to be the nearest allies, in the more strikingly patterned wings, grayish pattern of the mesonotal præscutum, and the structure of the male hypopygium, especially of the inner dististyle. The pattern of the wing is more like that found in *T.* (*S.*) *macrotrichiata* Alexander, which, however, has distinct macrotrichia in the outer cells of the wing, as discussed at the conclusion of the preceding species. Despite this presence of macrotrichia, the relationship between the members of the *macrotrichiata* and *variicornis* groups is very close, indeed.

TIPULA (SCHUMMELIA) IMANISHII sp. nov. Plate 1, fig. 5; Plate 2, fig. 29.

Belongs to the *continuata* group; allied to *jocosipennis;* mesonotal præscutum obscure yellow, with three opaque dark gray stripes that are indistinctly bordered by blackish; posterior yellow interspaces narrow or suffused with dusky; wings with the ground color creamy, with certain of the veins seamed with darker, the wing tip unclouded; male hypopygium with the inner dististyle produced into a slender subterminal beak.

Male.—Length, about 10 to 11 millimeters; wing, 12.5 to 13.5.

Female.—Length, about 15 millimeters; wing, 14.

Frontal prolongation of head yellow above, abruptly dark brown laterally; nasus distinct; palpi brownish black. Antennæ with scape obscure yellow, a little darker outwardly; pedicel pale yellow; flagellum brownish black; antennæ (male) moderately long, if bent backward extending about to root of halteres. Front and median area of anterior vertex yellow; posterior vertex and sides of anterior vertex weakly infumed.

Mesonotal præscutum obscure yellow, with three opaque dark gray stripes that are indistinctly bordered by blackish; posterior interspaces narrowly yellow to almost obliterated by dusky suffusions; scutum and mediotergite dark gray, each with a narrow median pale line; scutellum obscure yellow, with a capillary brown vitta. Pleura obscure yellow, conspicuously variegated by brownish gray. Halteres dusky, the knobs yellow. Legs with the femora obscure yellow, the tips conspicuously blackened; tibiæ and tarsi dark brown. Wings (Plate 1, fig. 5) with the ground color creamy, the prearcular region and costal cell brighter yellow, cell Sc slightly darkened; restricted obliterative

areas before and beyond stigma and across cell 1st M_2; veins bordered with brown, most heavily and distinctly on m-cu, Cu, and 2d A, the other veins less sensibly darkened. Venation: Cell 1st M_2 small; cell 2d A narrow.

Abdomen with basal five tergites obscure yellow, the lateral portions darkened; remaining segments, including hypopygium, brownish black. Male hypopygium (Plate 2, fig. 29) with the caudal margin of the ninth tergite, *9t,* broadly and evenly rounded. Inner dististyle, *id,* somewhat of the type of *jocosipennis;* that is, without caudal extension and with a subapical beak; in the present fly, this beak lies farther distad and is distinctly slenderer than the similar beak of *jocosipennis.*

Habitat.—Japan (Honshiu).

Holotype, male, Mount Kurobegoro, Echiu, in subalpine meadow, altitude 7,800 feet, August 8, 1931 (*Imanishi*). Allotopotype, female. Paratopotype, male.

Tipula (*Schummelia*) *imanishii* is respectfully dedicated to the collector, Mr. K. Imanishi, to whom I am indebted for valuable coöperation in studying the Japanese Tipulidæ. The fly needs comparison only with *jocosipennis* sp. nov., differing most evidently in the distinct thoracic coloration, obscure wing pattern, and in the structure of the male hypopygium, notably the position and slenderness of the beak of the inner dististyle.

TIPULA (ACUTIPULA) INTACTA sp. nov. Plate 2, fig. 30.

Belongs to the *fulvipennis* group; allied to *turbida;* antennal flagellum uniformly dark brown; mesonotal præscutum with four brown stripes that are more or less confluent on cephalic portion of sclerite; tips of femora blackened; tarsi chiefly light yellow; wings with the ground color conspicuously darkened, restricting the whitish hyaline areas to a major spot before cord, the extreme bases of the outer medial cells and the usual areas in cells M and Cu; median lobe of ninth tergite of male hypopygium simple.

Male.—Length, about 14 millimeters; wing, 16.5.

Frontal prolongation of head dark colored; nasus distinct; palpi dark, paler at incisures, the terminal segment broken. Antennæ dark brown, terminal segment reduced to a tiny button. Head dark brown.

Pronotum brown. Mesonotal præscutum with four relatively ill-defined brown stripes, all more or less confluent on cephalic portion of sclerite, the capillary pale median vitta well indicated behind; scutum and scutellum chiefly dark brown; medio-

tergite more or less denuded in the unique type, the posterior and lateral portions with a dense golden pollen. Pleura chiefly pale yellow. Halteres long, brown, the extreme base of stem paler. Legs with coxæ greenish yellow; trochanters yellow; femora yellow at bases, passing into brown, the tips conspicuously blackened; tibiæ brown, the tips narrowly darkened; tarsi paling to light yellow, the outermost segments broken; tibial spur formula 1–2–2. Wings with the pattern almost as in *brunirostris* and similar species; costal cell not conspicuously darkened, Sc a trifle more infumed; dark area in cell Cu distinct, placed before midlength of the basal section of Cu_1. All branches of M and distal section of Cu_1 with sparse but evident macrotrichia; squama with a few short setæ.

Basal abdominal segments brown, the caudal margins narrowly paler; outer segments, including hypopygium, more uniformly darkened. Male hypopygium (Plate 2, fig. 30) with the median lobe of the tergite, *9t*, entire, at apex set with sparse blackened spicules. Outer dististyle, *od*, entirely pale, broad basally, narrowed to the subacute apex. Inner dististyle, *id*, conspicuously tripartite, the two outer lobes with dense groups of erect yellow setæ, the apical lobe much broader and stouter than the others, separated from the intermediate lobe by a shallow rounded notch. Eighth sternite, *8s*, with the caudal portion narrowed, the apex truncate and set with short setæ that are shortest near the meson; before apex on ventral surface with a median swollen area set with longer yellow setæ.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 8,500 feet, July 18, 1931 (*Franck*).

The present species differs from *princeps* Brunetti, *shirakii* Edwards, *brunnirostris* Edwards, and other similar allied species in the Oriental and Eastern Palæarctic faunal regions in the simple lobe of the ninth tergite of the male hypopygium. In the latter character, it agrees more closely with a small group of Eastern Palæarctic forms that center about *bubo* Alexander, as *kuzuensis* Alexander and *turbida* Alexander, differing in the wing pattern and details of the male hypopygium.

TIPULA (ACUTIPULA) SUBTURBIDA sp. nov. Plate 1, fig. 6; Plate 2, fig. 31.

Belongs to the *fulvipennis* group; allied to *bubo* and *turbida;* antennæ with scape and pedicel yellow, flagellum dark brown; præscutal stripes ill-defined; wings with a conspicuous dark pat-

tern, the outer half of cell R_5 nearly hyaline; male hypopygium with the median lobe of the ninth tergite simple.

Male.—Length, about 14 millimeters; wing, 16.

Frontal prolongation of head relatively stout, uniformly dark brown; palpi pale brown, terminal segment broken. Antennæ with the scape and pedicel yellow; flagellum dark brown, the basal enlargements of the segments more intense, the outer segments more uniformly darkened; verticils long and conspicuous, a trifle longer than the segments alone. Head dark brown.

Mesonotal præscutum light gray, with four scarcely indicated darker grayish brown stripes; mediotergite with a lighter gray pruinosity. Pleura obscure brownish yellow, the pleurotergite a little darker. Halteres relatively long, brown, the apex of knob paler. Legs with the coxæ pruinose; trochanters obscure yellow; remainder of legs broken. Wings (Plate 1, fig. 6) with a dark pattern that is much as in *turbida;* prearcular region and cells C and Sc dark brown; whitish area before cord more restricted; distal half of cell R_5 nearly hyaline.

Abdominal tergite one chiefly infuscated; succeeding segments light yellow, with a narrow sublateral brown stripe that widens on the third and following segments, the outer portion of organ, including hypopygium, chiefly dark brown. Male hypopygium as in *bubo* and allies, the median lobe of the tergite being simple and weakly spinulose. Eighth sternite with numerous short setæ at caudal end. The chief distinctions between species of the present group are to be found in the conformation and armature of the inner dististyle (Plate 2, fig. 1, *id*). Ninth sternite with a conspicuous brush of yellow setæ lying in the median notch.

Habitat.—China (Szechwan).

Holotype, male, Pehlinting, Mount Omei, altitude 6,000 feet, July, 1931 (*Franck*).

Tipula (*Acutipula*) *subturbida* is allied to *bubo* Alexander and *turbida* Alexander, both of Japan, differing especially in the wing pattern and details of the male hypopygium, especially of the inner dististyle.

TIPULA SAKAGUCHIANA sp. nov. Plate 1, fig. 7; Plate 2, fig. 32.

Allied to *nigrocostata;* antennæ bicolorous, in male, if bent backward, extending about to the second abdominal segment; wing with costal border brownish black, remainder of disk pale brown, variegated by creamy areas; cell M_1 very short-petiolate; male hypopygium with the tergite divided by pale yellowish

membrane, on either side with an acute curved spine; basistyle produced.

Male.—Length, 15 millimeters; wing, 16; antenna, about 6.

Frontal prolongation of head relatively stout, grayish brown; nasus long and slender; palpi brown. Antennæ (male) elongate, but still shorter than in *nigrocostata,* if bent backward extending about to the second abdominal segment; antennæ with scape and pedicel yellowish brown; basal flagellar segments weakly bicolorous, the basal enlargements of the second and succeeding segments dark brown, the apices paler; outer segments more uniformly darkened; verticils stout, not exceeding one-half the length of the segments; terminal segment minute, thimble-shaped. Head brownish gray.

Mesonotal præscutum light gray, with three somewhat darker gray stripes that are narrowly bordered by darker brown, the median stripe with a central vitta of this color on anterior half; posterior sclerites of mesonotum dark gray. Pleura pale buffy gray, variegated with darker gray areas on anepisternum, ventral sternopleurite, and meron; pleura glabrous. Halteres elongate, brownish yellow, the knobs dark brown. Legs with the coxæ whitish; trochanters yellow, remainder of legs broken. Wings (Plate 1, fig. 7) with a faint brown tinge; prearcular region yellow; cells C and Sc brownish black, the color not involving any part of the radial field; stigma slightly paler brown; somewhat more cream-colored areas, as follows: Before stigma; as an incomplete fascia beyond cord and stigma, extending from basal half of cell R_2 through cell 1st M_2; in cell M, on either side of a more dusky area at near midlength of the cell; veins dark brown, the prearcular veins more yellowish. Squama naked; trichia of veins numerous and well-distributed, including all veins beyond cord and on outer ends of principal basal veins. Venation: R_{1+2} entire, rather strongly upcurved; cell M_1 short-petiolate, the petiole being approximately one-half m; m-cu just beyond fork of M_{3+4}, at about one-third the length of cell.

Abdomen with the basal tergites yellow, with a dark brown median stripe that is narrowly interrupted at the caudal margins of the segments, widened on the outer tergites, the eighth segment chiefly infuscated, the ninth tergite again yellow, except for the caudal sclerotized armature; sternites yellow, the caudal margins of the segments narrowly darkened, the eighth sternite uniformly infuscated; hypopygium yellow. Male hypopygium (Plate 2, fig. 32) with the suture between the tergite, *9t,* and sternite, *9s,* complete except for about the cephalic fifth. Basi-

style, *b*, entirely separated from sternite, the outer end narrowed and produced to extend to opposite the tips of the inner dististyles, *id*. Ninth tergite, *9t*, viewed dorsally, entirely divided by pale membrane, the caudal margin on either side with an arched blackened thorn or spine, their tips acute; viewed from the side, the thorns are produced caudad and ventrad into flattened blackened plates; between the two blackened masses on either side is a high, compressed, pale membrane. Eighth sternite slightly sheathing, its apex with longer and more abundant setæ.

Habitat.—Japan (Honshiu).

Holotype, male, Kaisogun, Kii, altitude about 325 feet, August, 1929 (*Sakaguchi*).

I take pleasure in dedicating this beautiful species of *Tipula* to my friend Prof. S. Sakaguchi, who has added materially to our knowledge of the crane flies of the Riukiu Islands and Honshiu. The only near ally of this fly is *T. nigrocostata* Alexander (Kyūshū), which, while very similar in general appearance, differs in the longer, less distinctly bicolorous antennæ, the short cell M_1 of the wings, and the details of the male hypopygium, more especially of the tergite, where the dorsal spines are shorter and the median area is more solidly sclerotized.

TIPULA (VESTIPLEX) SERRIDENS Alexander. Plate 3, fig. 33.

Tipula serridens ALEXANDER, Trans. Am. Ent. Soc. 46 (1920) 18–19.

The type of this interesting fly was a female, taken in the Province of Musashi, Honshiu, in May, 1919. The male remained unknown until a small series was taken on Mount Daisen, Hôki, altitude 3,900 to 5,560 feet, June 7, 1930, by Hibi. The following description is given, since the male differs in several important regards from the female. The ground color of the wings, and especially the costal border, is darker, more brownish than in the holotype female, and the legs are much darker colored.

Male.—Length, about 15 to 16 millimeters; wing, 16 to 17.5.

Frontal prolongation of head dark gray; nasus short and stout; palpi brownish black. Antennæ of moderate length; scape and pedicel yellowish brown to brown; flagellum black; flagellar segments strongly incised to appear binodose. Head light gray, with a capillary brown line.

Mesonotal præscutum clear light gray, with four darker gray stripes that are narrowly but conspicuously bordered by bright brown, broadest and most distinct on the lateral stripes; inter-

mediate stripes wider and contiguous in front, narrowed and gradually divergent behind, not reaching the suture; posterior sclerites of mesonotum chiefly light gray, each scutal lobe with a small lunate mark at cephalolateral corner, immediately behind suture; scutellum with a capillary median brown vitta. Pleura gray; dorsopleural region buffy yellow. Halteres pale, the knobs chiefly yellow, the base of stem slightly darkened. Legs with coxæ light gray; trochanters grayish yellow; femora obscure yellow on slightly more than proximal half, thence passing into dark brown; tibiæ dark brown, the tips slightly darker; tarsi black; tibial spur formula 1–2–2; claws with a small basal tooth. Wings with the ground color rather dark brown, variegated by whitish areas, including an incomplete, rather narrow, cross-band beyond cord, extending from costa to near midlength of cell M_3, including the outer half of cell Sc_2, basal third of R_2, narrow subbasal portions of cells R_3 and R_5 and most of 1st M_2; additional large white areas near outer end of cell M and in bases of Cu and 1st A; cell R_1 before stigma chiefly white; prearcular region clear yellow; cell C brown, Sc more yellowish brown; stigma oval, dark brown; brown clouds at origin of Rs and on anterior cord; veins brown, pale in the obliterative areas. Squama naked. Vein R_{1+2} with about eight trichia, distributed on about the basal half; short trichia on all veins beyond cord, excepting the distal third of R_3. Venation: R_{1+2} entire, both it and R_3 pale at outer end; m about one-half the petiole of cell M_1; m-cu at fork of M_{3+4}.

Abdomen with the basal tergite grayish brown; segments two to four yellow, with a brown median vitta that widens on the outer segments; tergites five to eight black, sparsely pruinose, the lateral margins narrowly pale; sternites five to nine more strongly pruinose; styli of hypopygium yellow. Male hypopygium (Plate 3, fig. 33) with the tergite separated from the sternite. Basistyle embedded in membrane, thus separated from sternite. Ninth tergite, *9t*, appearing as a chitinized saucerlike structure, the margins smooth; viewed laterally, the inner blackened rim appears higher than the outer margin. Inner dististyle, *id*, relatively slender, with conspicuous setæ. Ventral portion of basistyle produced dorsad and caudad as a slender rod that terminates in an acute blackened point. Eighth sternite unarmed.

Allotype, male, Mount Daisen, Hôki, altitude 4,550 feet, June 7, 1930 (*Hibi*).

There are two distinct ways in which the allotype, or type of the opposite sex from that of the holotype or lectotype, may be selected. It may either be part of the *original series* of specimens and be chosen from such series either by the original author or a subsequent author; or, it may be a specimen quite *apart* from the *original series,* selected at a subsequent date by the original describer of the species or by any later student. Probably far more than one-half of all described insects have been based upon a single or unique type, and according to the first interpretation of the word "allotype," such species could never be represented by a specimen of the opposite sex. In recent years, certain writers have suggested additional type categories to accommodate the second option above listed; that is, the selection of an allotype from material not on hand at the time of the original description of the species. Betrem [2] proposed for such a type the term "allolectotype," not being acquainted with the earlier term "lectoallotype," proposed by Curran two years earlier.[3] In the opinion of the present writer, both of these latter terms are synonyms of the original definition of "allotype," as proposed by Muttkowski.[4] This writer clearly says: "The allotype need not be described by the protologist (first describer); it can be contained in the original as well as any subsequent description by other authors. Thus, if the protolog describes only a holotype male, the first female subsequently described is to be called the allotype." In the light of this clear exposition of what was intended in the original proposal of this term, it would seem that if two distinct terms were required to accommodate the two possibilities above listed it would be necessary to propose a new term for the case where the second sex is described coincidentally with the definition of the holotype. In any case, the present writer intends to continue to use the term "allotype" as was originally intended by the first proposer of the term.

TIPULA QUADRISPICATA sp. nov. Plate 1, fig. 8; Plate 3, fig. 34.

Allied to *tetracantha;* male hypopygium with the outer dististyle broad, narrowed into a long, straight, spikelike point; basal portion of inner dististyle produced into a conspicuous blackened rod that is unequally bispinous at apex.

[2] Treubia 9 supplement (1928) 3.
[3] Can. Entomol. 58 (1926) 311.
[4] Bull. Public Mus. Milwaukee 1 (1910) 10.

Male.—Length, about 16 millimeters; wing, 17.4.

Frontal prolongation of head obscure yellow; nasus conspicuous; palpi light brown, the outer segment darker. Antennæ with the scape and pedicel yellow; flagellar segments brown, the base of each segment obscure yellow, on the first segment including more than one-half the segment, on the remaining segments becoming less in amount, the outer segments uniformly darkened. Head light gray.

Mesonotal præscutum light gray, with four scarcely differentiated darker gray stripes; posterior sclerites of mesonotum gray, the scutellum obscure yellow with a median brown vitta. Pleura clear light gray; dorsopleural region buffy. Halteres pale, the knobs weakly infuscated. Legs with the coxæ sparsely pruinose; trochanters yellow; femora yellowish brown, the tips narrowly blackened; tibiæ brown; tarsi brownish black. Wings (Plate 1, fig. 8) with a strong brownish yellow tinge, cell Sc and prearcular region more yellow; stigma elongate, dark brown; veins dark brown. Obliterative areas very restricted, appearing at end of Rs and adjoining veins, and on basal sections of vein M_{1+2} and M_3, crossing cell 1st M_2. Venation: Petiole of cell M_1 a little more than one-half m.

Basal abdominal tergites yellow, the outer segments becoming dark brown, margined laterally and caudally with pale; sternites yellow. Male hypopygium with the tergite distinct from sternite except about on cephalic sixth. Basistyle fused with sternite except on ventral portion. Ninth tergite (Plate 3, fig. 34, 9*t*) extensive, gradually narrowed outwardly, terminating in two slender, blackened, spinulose lobes that are separated by a broad U-shaped notch. Outer dististyle, *od*, a broad rod that suddenly narrows to a long spikelike point. Inner dististyle, *id*, with the basal portion produced into a blackened rod, its apex unequally bispinous.

Habitat.—Japan (Honshiu).

Holotype, male, Kaisogun, Kii, June, 1930 (*Sakaguchi*).

Tipula quadrispicata is closely allied to *T. tetracantha* Alexander (Honshiu, Shikoku, Kiushu), differing conspicuously in the structure of the tergite and styli. These parts are shown for *tetracantha* (Plate 3, fig. 35) as a basis for comparison between the two species. Both of these flies have a pair of fingerlike lobes pendant from the ninth sternite. The species differ from the other known Japanese species of *Tipula* in having the bases of the individual flagellar segments pale yellow, contrasting with the brown remainder of the segment.

TIPULA CURVICAUDA Alexander. Plate 3, figs. 36 to 39.

Tipula curvicauda ALEXANDER, Ann. Ent. Soc. Am. 16 (1923) 72–73.

The type was a male from Kamikohti, Shinano, Honshiu, taken July 13, 1918, by Issiki. Additional material has since come to hand from other parts of the mountains of Honshiu, as follows: One male, Yumoto, Shimotsuke, altitude 4,800 feet, July 22, 1923 (*Esaki*); one female, Hinoëmata, Iwashiro, altitude 4,000 feet, July 24, 1923 (*Esaki*).

The allotype female may be briefly diagnosed. Length, about 24 millimeters; wing, 23. Characters as in male, differing in the sexual features only. Ovipositor with the cerci long, slender, straight; hypovalvæ relatively high and compressed.

Allotype, female, Hinoëmata, Iwashiro, July 24, 1923 (*Esaki*).

The following description of the remarkable male hypopygium is taken from the holotype male.

Male hypopygium (Plate 3, fig. 36) large and conspicuous, subglobular, tilted at an angle to the remainder of abdomen. Ninth tergite (Plate 3, fig. 37, *9t*) massive, the caudal margin with a very broad U-shaped notch, the lateral angles formed being very thick and obtusely rounded, on their ventral margin produced into an obtuse black tooth; on the ventral floor of the notch lie two parallel, broad-based teeth, with blunt tips, separated from one another only by a narrow split. Basistyle, *b*, and sternite, *9s*, united, except for a curved suture beneath. Outer dististyle (Plate 3, fig. 38, *od*) very remarkable, appearing as a long, powerful, terete arm that is strongly curved before midlength, the outer face clothed with long yellow setæ, the apex a little enlarged, obliquely truncated and provided with one or more spines. Inner dististyle (Plate 3, fig. 39, *id*) correspondingly small, heavily blackened. Ninth sternite, *9s*, deeply notched, the area cephalad of the notch membranous, the proximal margins very tumid and provided with dense long setæ. Eighth sternite, *8s*, unarmed.

TIPULA NIGROSIGNATA Alexander.

Tipula nigrosignata ALEXANDER, Ann. & Mag. Nat. Hist. IX 14 (1924) 472–473.

Described from a unique male, Lake Chuzenji, Shimotsuke, Honshiu, altitude 4,170 feet, July 22, 1923 (*Esaki*). The female sex is now known and is described herewith as allotype.

Female.—Length, about 21 millimeters; wing, 22.

Characters as in the male, except for the sexual differences of short antennæ. Anepisternum and sternopleurite conspicuously

blackened. Bases of fore and middle coxæ darkened. Ovipositor with cerci long and very slender, the margins smooth.

Allotype, female, Mount Shirouma, Shinano, Honshiu, August 8, 1931 (*Machida and Nakamura*).

TIPULA SEMPITERNA sp. nov. Plate 1, fig. 9; Plate 3, figs. 40, 41.

Mesonotal præscutum with the ground color blackish, with four dark gray stripes; anterior lateral pretergites and dorsopleural region bright yellow; ventral pleurotergite obscure yellow; legs chiefly black, the femora bases broadly yellow, narrowest on the forelegs; wings yellow, variegated with brown, including the wing tip; Rs approximately twice m-cu; male hypopygium with the caudal margin of tergite bearing two triangular spinous lobes; outer dististyle flattened, long and narrow, the apex truncate.

Male.—Length, about 12 millimeters; wing, 16.2.

Frontal prolongation of head grayish brown; nasus distinct; palpi black. Antennæ black throughout, if bent backward not extending to beyond wing root; flagellar segments feebly incised; verticils shorter than the segments. Head brownish gray, the front and anterior vertex clear light gray; vertical tubercle a small but conspicuous conical point.

Anterior pronotum dark brown medially and on the sides, variegated by obscure yellow sublaterally; posterior pronotum and anterior lateral pretergites deep yellow. Mesonotal præscutum with the ground color dull black, with four clear gray stripes, the humeral region and lateral margin yellow; scutum with the lobes chiefly dark gray, variegated with blackish along the suture, the median area of scutum light gray; posterior sclerites of notum gray. Pleura light gray, the ventral pleurotergite abruptly light yellow; dorsopleural region bright yellow. Halteres obscure yellow. Legs with the coxæ gray, their tips pale yellow; trochanters obscure yellow; femora black, their bases yellow, narrowest on the forelegs where less than one-third is included, widest on the middle and hind legs where about the distal third is blackened; tibiæ and tarsi black; tibial spur formula 1–2–2, the mid-tibia with one spur reduced in size, not exceeding one-half the length of the other; claws simple. Wings (Plate 1, fig. 9) with a strong cream-yellow tinge, the prearcular and costal regions brighter yellow; stigma dark brown; wing tip narrowly infuscated; a broad brown seam on anterior cord; narrower dark seams on posterior cord, vein Cu, and vein 1st A; less distinct washes in cell R and at outer end of cell

1st A; veins dark brown, brighter in the costal and prearcular regions. Macrotrichia beyond cord numerous; squama naked. Venation: Rs relatively long, nearly twice m-cu; R_{1+2} entire; m-cu on M_4 shortly beyond fork.

Abdominal tergites dark brown, the lateral borders of the basal segments yellowish; basal sternites yellow; outer segments, including hypopygium, uniformly darkened. Male hypopygium (Plate 3, figs. 40, 41) relatively small, black, only the outer dististyle obscure yellow. Tergite, *9t,* entirely separate from the sternite. Basistyle, *b,* separated from the sternite by a suture that is broken on the cephalic portion, the caudal end of basistyle narrowed and produced; median region of sternite membranous, the caudal portion slightly produced as a flattened lobule. Ninth tergite, *9t,* large, the caudal margin produced into two, small, triangular lobes which are separated by a notch that has about the same outline; viewed laterally, each of these lobes bears numerous, small, blackened points on ventral surface; ventrocaudal portion of tergite with a small, blackened, spinous point that is directed ventrad. Outer dististyle, *od,* flattened, relatively long and slender, the apex truncate. Inner dististyle, *id,* bearing a conspicuous, heavily blackened, outer spine, best seen from a ventral aspect; apex of style similarly blackened. Caudal margin of eighth sternite, *8s,* straight, unarmed.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Kurobegoro, Echiu, in subalpine meadow, altitude 7,800 feet, August 8, 1931 (*Imanishi*).

Tipula sempiterna has no close ally in the Japanese fauna. It bears a certain general resemblance to species such as *T. machidai* Alexander and *T. otiosa* Alexander, but is a very different fly.

TIPULA HIBII sp. nov. Plate 1, fig. 10.

Generally similar to *hylæa;* general coloration gray, the præscutum with a brown median stripe and less-distinct lateral stripes; knobs of halteres yellow; fore femora chiefly blackened, hind femora yellow, passing to black before tips; extreme tips of all femora narrowly but conspicuously reddish; tibiæ yellow, the tips narrowly dark brown; wings pale cream-yellow, with a cross-banded pattern of brown and gray; prearcular region and cell Sc light yellow, cell C dark brown; vein R_{1+2} atrophied.

Female.—Length, about 14 millimeters; wing, 14.

Frontal prolongation of head buffy, sparsely light gray pruinose; nasus slender; palpi dark brown. Antennæ with the scape

and pedicel light yellow; flagellum broken. Head light gray, with indications of a very pale brown median vitta on vertex.

Mesonotum clear light gray, with a broad, conspicuous, median, brown stripe and much paler lateral stripes. Pleura clear gray; dorsopleural membrane very pale yellow. Halteres pale yellow, the extreme base of knob dusky, the majority of knob light yellow. Legs with the coxæ light gray; trochanters obscure yellow; fore femora chiefly blackened, the base narrowly brightened; middle femora obscure yellowish brown to brown, deepening to brownish black before tip; posterior femora obscure yellow, before tips with a broad black ring; tips of all femora very narrowly but conspicuously reddish; tibiæ light yellow, the tips narrowly dark brown; tarsi dark brown; tibial spur formula 1–2–2; claws (female) small, simple. Wings (Plate 1, fig. 10) with the ground color pale cream-yellow, the prearcular region and cell Sc clear light yellow; cell C dark brown except on basal portion; stigma and a relatively narrow crossband on anterior cord dark brown; wing apex in radial field dark brown; paler brownish gray clouds on posterior cord and as a broken fascia before level of origin of Rs, interrupted in cell Cu; outer half of cell 2d A similarly clouded; veins of outer medial field, extreme outer end of cell M, and outer two-thirds of vein 2d A narrowly seamed with dark brown; veins pale yellowish, brown where traversing the darkened areas. Squama naked; long, conspicuous macrotrichia on veins beyond cord. Venation: R_{1+2} atrophied; petiole of cell M_1 long, fully three or more times m.

Abdominal tergites obscure yellow, with a conspicuous median brown stripe that is broadly interrupted at the caudal margins of the segments; basal sternites a little variegated with yellow. Ovipositor with cerci and hypovalvæ straight, both relatively slender, with smooth margins.

Habitat.—Japan (Honshiu).

Holotype, female, Kyusho Mountain, Hôki, June 13, 1930 (*Hibi*).

I take great pleasure in naming this beautiful *Tipula* in honor of the collector, who has secured numerous interesting Tipulidæ in various parts of Hôki. The species is most generally similar to *T. hylæa* Alexander, in the venation and wing pattern, differing in the yellow knobs of the halteres, and, especially, the variegated pattern of the legs, which, in *hylæa*, are uniformly dark brown. *Tipula quadrifasciata* Matsumura (*aluco* Alexander) is also somewhat similar but again differs in the uniformly

darkened legs and knobs of halteres, and in the more cross-banded pattern of the wings, including a broad fascia across cells R and M beyond the arculus.

TIPULA LEGALIS sp. nov. Plate 1, fig. 11; Plate 3, fig. 42.

Antennæ with scape yellow, the remaining segments brownish black; mesonotal præscutum grayish yellow, with three conspicuous blackish stripes, the median one with its center somewhat paler; femoral tips broadly black; wing pattern much as in *cruciata;* outer ends of radial cells uniformly darkened; basal segments of abdomen yellowish, the outer segments black; male hypopygium with the tergite trilobed at apex, the median lobe longest; outer dististyle narrowly and weakly sinuous; eighth sternite with two groups of setæ.

Male.—Length, about 13 millimeters; wing, 13.

Frontal prolongation of head dark brown, a trifle brighter laterally at base; nasus long and slender; palpi dark brown, the terminal segment restrictedly brighter at tip. Antennæ with the scape yellow, a little darkened basally on mesal face; pedicel and flagellum brownish black; flagellar segments with the basal enlargement relatively conspicuous, with elongate verticils. Head dark gray, the anterior vertex behind the antennal bases paler.

Mesonotal præscutum with the ground color grayish yellow, with three conspicuous blackish stripes, the median stripe slightly paler in center; posterior sclerites of mesonotum chiefly blackened, the median region of scutum and mediotergite sparsely pruinose. Pleura chiefly covered by a heavy yellowish pollen, the dorsal portion of the pleurotergite abruptly darkened; dorsopleural membrane buffy; ventral sternopleurite and meron more darkened. Halteres with stem pale yellow, the knobs dark brown. Legs with the coxæ sparsely pruinose, especially the fore and middle coxæ; trochanters yellow; femora yellow, the tips broadly and abruptly black; tibiæ obscure yellow, the tips more narrowly blackened; tarsi passing from brown to black; tibial spur formula 1–2–2; claws with a single basal spine or tooth. Wings (Plate 1, fig. 11) with pattern much as in *cruciata,* the white band beyond cord reaching costa only as a narrow point in cell R_2; outer ends of all radial cells uniformly darkened; markings of basal cells almost as in *cruciata* but not so strongly contrasted. Squama naked. Venation: Rs more than twice as long as m-cu; R_{1+2} entire; basal section of R_{4+5} short but evident, less than r-m; cell 1st M_2 relatively small and short.

Basal four or five abdominal segments yellowish, the remaining segments, including hypopygium, black. Male hypopygium (Plate 3, fig. 42) with the tergite and basistyle entirely cut off by sutures. Ninth tergite, *9t*, with the caudal margin unequally trilobed, the median lobe longer, the lateral lobes with the outer mesal angle weakly produced into a blackened point. Outer dististyle, *od*, slender, weakly sinuous, the slightly expanded apex very obliquely truncated. Inner dististyle, *id*, with the lobe at base on outer margin small and obtuse. Eighth sternite, *8s*, moderately sheathing, with long yellow setæ that are arranged in two more or less distinct groups or brushes and become decussate across the midline, with a single marginal row of similar setæ extending across the midline.

Habitat.—China (Szechwan).

Holotype, male, Pehlingting, Mount Omei, altitude 6,000 feet, July, 1931 (*Franck*).

The nearest described ally of this fly seems to be *Tipula cruciata* Edwards (Tibet to Sikkim), which differs notably in the thoracic pattern and less evidently in the structure of the male hypopygium. In *cruciata*, the basal section of vein R_{4+5} is obliterated or nearly so; in the present fly the element is short but distinct.

TIPULA ILLEGITIMA sp. nov. Plate 1, fig. 12.

General coloration of mesothorax gray, the præscutum with scarcely indicated darker gray stripes; basal four or five segments of antennæ light yellow, the succeeding segments darker; wings whitish subhyaline, with a diffuse pale brown pattern, darkest in the outer radial field; pale crossband beyond cord incomplete; R_{1+2} almost entirely atrophied; abdomen obscure yellow, both the tergites and sternites with a conspicuous median brown stripe.

Female.—Length, about 15 millimeters; wing, 12.5.

Frontal prolongation of head relatively long, pale brownish gray; nasus short, tipped with long yellow setæ; palpi dark brown, the extreme tip of the last segment reddish. Antennæ with the scape, pedicel, and basal two flagellar segments light yellow, the succeeding segments passing into brown, the basal enlargements of the segments somewhat darker; dorsal verticils elongate, much exceeding the ventral pair. Head light gray.

Mesonotal præscutum gray, with slightly darker gray stripes that are very little evident; interspaces with sparse brownish setigerous punctures; posterior sclerites of mesonotum gray, the

scutellum with a median brown vitta. Pleura gray, the dorsopleural region more buffy. Halteres yellow, the knobs weakly darkened. Legs with the coxæ pruinose; trochanters yellow; femora and tibiæ obscure yellow, the tips passing into brown; tarsi brown; tibial spur formula 1–2–2. Wings (Plate 1, fig. 12) whitish subhyaline, with a diffuse pale brown pattern, darkest in the stigmal region and in the outer ends of cells R_2 and R_3; cell C yellowish brown, distinctly darker in color than the clear yellow cell Sc; pale crossband beyond cord narrow, extending from costa into basal third of M_3, including approximately one-fourth to one-fifth the length of the radial cells it traverses; pale area in outer ends of cells R and M relatively restricted; veins chiefly yellow. Venation: R_{1+2} atrophied, indicated only by a slight basal spur without macrotrichia; Rs about one-half to two-thirds longer than m-cu; cell 1st M_2 small.

Abdomen obscure yellow, both the tergites and sternites with a conspicuous brown median line. Ovipositor with the cerci long, straight, and slender.

Habitat.—Japan (Honshiu).

Holotype, female, Mount Ohdai, Yamato, altitude 2,600 feet, June 5, 1930 (*Sakaguchi*).

Of the Japanese species of *Tipula* in which R_{1+2} is entirely or chiefly atrophied (*autumna* Alexander, *flavocostalis* Alexander, *futilis* Alexander, *hylæa* Alexander, *manca* Alexander, *phæopasta* Alexander, *pluriguttata* Alexander, *quadrivittata* Matsumura, *subfutilis* Alexander, *taikun* Alexander, *trupheoneura* Alexander), the present form is most similar to *flavocostalis,* differing in the body coloration and in the wing pattern, as the more cream-yellow ground color and the very diffuse pale brown pattern. In *flavocostalis,* vein R_{1+2} is represented by a short spur that is provided with a few macrotrichia.

TIPULA TRUPHEONEURA Alexander. Plate 4, fig. 43.

Tipula trupheoneura ALEXANDER, Trans. Am. Ent. Soc. 46 (1920) 17–18.

The unique type, a female, was from Saitama, Musashi, Honshiu, collected May 31, 1919, by Takahashi. An additional male and a female were taken on Mount Daisen, Hôki, altitude 3,900 to 5,200 feet, June 7, 1930, by Hibi. The male is herewith characterized as allotype.

Male.—Characters as in the female, including the infuscated, weakly pruinose antennal scape. Male hypopygium with the tergite separated from the sternite by a suture. Ninth tergite

(Plate 4, fig. 43, 9*t*, *a*) appearing as a subquadrate plate, its caudal margin subtransverse, with a deep and narrow, parallel-sided, median notch; caudal margin on either side of median notch with microscopic denticles. Basistyle complete, its caudal margin not produced, as is the case in the similar species, *pollex* sp. nov. Outer dististyle, *od*, *a*, relatively small, with conspicuous setæ. Inner dististyle broad, the outer ventral angle produced into a fingerlike lobe. Ninth sternite on mesial portion, immediately adjoining the basistyle, produced into a blackened spikelike point, the oval area from which the spine arises surrounded by membrane. This structure must function almost as a gonapophysis, yet is evidently a development of the sternite (fig. 43, 9*s*, *a*). Eighth sternite unarmed and scarcely sheathing; its median portion is less strongly sclerotized, especially near the caudal margin, forming a pale triangular area destitute of, or with more sparse, setæ; from beneath the caudal margin of the sternite protrudes pale membrane that is usually hidden beneath the sclerite.

Allotype, male, Mount Daisen, Hôki altitude 3,900 feet, June 7, 1930 (*Hibi*).

An additional male, taken at Gokanosho, Higo, Kyūshū, altitude 700 feet, April 29, 1924 (*H. Hori*), has a slightly different hypopygium but still seems certainly to fall within the limits of the present species. Male hypopygium more heavily blackened. Ninth tergite, 9*t*, *b*, with the caudal margin less transverse, each lobe subtriangular in outline, its mesal slope with conspicuous denticles. The blackened spine on the ninth sternite, 9*s*, *b*, is somewhat stouter.

TIPULA POLLEX sp. nov. Plate 1, fig. 13; Plate 4, fig. 44.

Thorax clear ashy gray, the præscutal stripes scarcely evident; antennæ with scape and pedicel light yellow, flagellum black; fore femora extensively blackened, the remaining femora blackened only at tips; wings whitish, including a broad, almost complete crossband beyond cord; wing tip strongly infumed; R_{1+2} entire; basal abdominal segments yellow, the outer segments blackened; ninth tergite of hypopygium produced into a compressed median blade; basistyle produced into a compressed fingerlike lobe; eighth sternite unarmed.

Male.—Length, about 15 to 16 millimeters; wing, 15 to 16.

Frontal prolongation of head obscure yellow, slightly pruinose at base; nasus very short and blunt; palpi dark brown. Antennæ (male) of moderate length, if bent backward ending

shortly before base of abdomen; scape and pedicel light yellow; flagellum black. Head light ashy gray.

Mesonotum light ashy gray, the very slightly darker præscutal stripes almost obsolete. Pleura ashy gray, the dorsopleural region pale yellow. Halteres pale yellow, the knobs weakly darkened. Legs with the coxæ whitish pruinose; trochanters pale yellow; femora yellow basally, the tips conspicuously blackened, broadest on the forelegs, where about the outer three-fourths is included, very narrow on the middle and hind femora where only the tips are darkened; tibiæ brown; tarsi black; tibial spur formula 1–2–2; claws small, simple. Wings (Plate 1, fig. 13) with the ground color whitish, most apparent as a broad, nearly complete crossband beyond the cord, including approximately the basal half of cells R_2, R_3, and M_3, the basal two-fifths of R_5, and almost all of cell 1st M_2; other large areas of the ground color lie at two-thirds the length of cell M and before midlength of 1st A; wing tip broadly and conspicuously darkened, more intense in the radial field; stigma and a narrow seam on anterior cord dark brown; prearcular region and cells C and Sc light yellow; remainder of cells before cord a very pale brown; obliterative areas including the outer end of Rs and the basal sections of veins M_{1+2} and M_3; veins dark brown, flavous in the yellow areas. Macrotrichia on all longitudinal veins beyond cord; squama naked. Venation: R_{1+2} entire, with all but the base pale and without trichia; Rs more than twice the length of m-cu; cell 1st M_2 elongate, narrowed outwardly; petiole of cell M_1 about one-third longer than m.

Basal abdominal segments yellow, the tergites with a conspicuous median brown stripe that is almost continuous; fourth and succeeding tergites blackish, all but the last with broad, lateral, and less conspicuous pale caudal margins; sternites five to seven, inclusive, similar in color; hypopygium blackened. Male hypopygium (Plate 4, fig. 44) with the tergite and basistyle entirely separate; an additional small triangular sclerite cut from caudodorsal portion of ninth sternite, above the basistyle. Ninth tergite, *9t,* heavily sclerotized, the caudal margin with a highly compressed median blade. Basistyle, *b,* produced caudad into a flattened fingerlike lobe; ventrocaudal angle of basistyle produced slightly caudad beyond the level of the sternite. Inner dististyle, *id,* with the outer margin near base armed with several small spinous points, the more basal ones larger. Eighth sternite unarmed, its caudal margin evenly convex, not sheathing.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Daisen, Hôki, altitude 4,550 feet, June 7, 1930 (*Hibi*). Paratopotype, male, altitude 5,200 feet, June 7, 1930 (*Hibi*).

Tipula pollex is very similar to *T. trupheoneura* Alexander, differing in the persistence of vein R_{1+2}, the almost obsolete præscutal stripes, and the very different male hypopygium.

TIPULA SETICELLULA LONGILIGULA subsp. nov. Plate 4, fig. 45.

Almost exactly as in the typical form but with the lobe of the eighth sternite (Plate 4, fig. 45, 8*s*) of quite different form, being elongate, narrowed outwardly, the lobe fringed with long, conspicuous, darkened setæ. On either side of lobe, a loose pencil of elongate setæ.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Ohdai. Yamato, altitude 3,250 feet, June 5, 1930 (*Sakaguchi*). Allotopotype, female. Paratopotypes, 1 male, 1 female.

LIMONIINÆ

LIMONIINI

LIMONIA (DICRANOMYIA) SUSPENSA sp nov. Plate 1, fig. 14; Plate 4, fig. 46.

General coloration reddish brown; antennæ with short-oval flagellar segments; wings with a faint brown tinge, the stigma pale; distal section of vein M_3 lying suspended in membrane, both the basal section of M_3 and m atrophied; male hypopygium with two or three rostral spines.

Male.—Length, about 5 millimeters; wing, 5.5.

Female.—Length, about 6 millimeters; wing, 5.5.

Rostrum yellow; palpi short, brown. Antennæ pale brown; flagellar segments short-oval, becoming slightly longer at outer end of organ; verticils short, inconspicuous. Head pale brown.

Mesonotum and pleura pale reddish brown to darker liver brown, without evident markings; pleura very sparsely and vaguely pruinose. Halteres pale, the knobs weakly darkened. Legs with the coxæ and trochanters reddish brown; remainder of legs obscure yellow. Wings (Plate 1, fig. 14) with a faint brown tinge, the stigma scarcely darker; veins brown. Macrotrichia lacking on free tip of Sc_2, R_2, and on anterior cord except for distal half of basal section of R_{4+5}. Venation: Sc_1 ending approximately opposite origin of Rs, Sc_2 a short distance from its tip; distal section of M_3 suspended in the membrane of wing, with both m and basal section of M_3 atrophied; m-cu shortly before fork of M; cell 2d A wide.

Abdomen, including the hypopygium, reddish brown. Male hypopygium (Plate 4, fig. 46) with the caudal margin of tergite, *9t*, notched medially, the lateral lobes broadly rounded. Dorsal dististyle strongly curved. Ventral dististyle, *vd*, moderately large, exceeding the basistyle in area, the rostral prolongation long and slender, with two, or sometimes, three, rostral spines at its base, these arising from short, inconspicuous tubercles. Mesal-apical lobe of gonapophysis, *g*, slender, strongly curved, entirely pale.

Habitat.—Japan (Honshiu).

Holotype, male, Seto, Kii, strictly marine, June 10, 1930 (*Tokunaga*). Allotopotype, female. Paratopotype, 1 male.

Limonia (*Dicranomyia*) *suspensa* is the fourth marine crane fly belonging to this genus that has been discovered by Tokunaga at Seto.[5] The curious venation of the medial field of the wing is constant in all specimens before me and certainly appears to represent a normal condition which will serve to separate this fly from all other regional species. In this regard, the insect lies about midway between the conditions found in the subgenera *Dicranomyia* and *Alexandriaria*, the former having either m or the basal section of M_3, or both, preserved, while the latter group has m and both sections of M_3 atrophied. I am referring the species to the subgenus *Dicranomyia.*

LIMONIA (RHIPIDIA) GARRULOIDES sp. nov. Plate 1, fig. 15; Plate 4, fig. 47.

Mesonotum dark grayish brown, the præscutum with a darker brown median stripe; antennæ (male) only 11-segmented, the flagellum with eight branched segments; halteres whitish; tarsi chiefly snowy white; wings milky white, the apex and a broad seam along cord infuscated; Rs relatively short, only about one-half longer than R_{2+3}; caudal margins of intermediate segments narrowly pale.

Male.—Length, about 4 millimeters; wing, 4.4.

Rostrum and palpi dark brown. Antennæ only 11-segmented, dark brown, the apical pedicles white; basal eight flagellar segments bipectinate, only the terminal segment being simple; branches shorter than in *garrula*. Head dark grayish brown.

Pronotum dark brown, more yellowish pollinose dorsally. Mesonotum dark grayish brown, the præscutum with a median darker brown stripe. Pleura chiefly dark grayish brown, not clearly visible in the unique type. Halteres whitish. Legs with the coxæ and trochanters dark; femora brownish black, brightened

[5] Philip. Journ. Sci. 49 (1932) 112–115.

at bases, the fore femora yellow with only the tips narrowly blackened; fore tibiæ brownish yellow, the tips narrowly and vaguely darkened, remaining tibiæ brownish black; basitarsi snowy white, with only the extreme bases blackened, this slightly broader on the forelegs, where about one-sixth is included; posterior basitarsi with only a microscopic portion darkened; remainder of tarsi white, with only the terminal segment black. Wings (Plate 1, fig. 15) milky white, the apex and a broad area at the cord brown, a little less intense than the dark brown stigma, these two areas leaving a complete white crossband between them; region of arculus weakly darkened; veins pale in the ground, darker in the clouded areas. Venation: Sc_1 ending just beyond origin of Rs, Sc_2 not evident in the unique type; Rs relatively short, only about one-half longer than R_{2+3}; cell 2d A relatively narrow.

Abdomen brownish black, the caudal margins of the intermediate tergites narrowly paler; outer segments uniformly darkened; hypopygium, including the ventral dististyle, darkened. Male hypopygium (Plate 4, fig. 47) with the tergite, *9t*, transverse, the caudal margin notched to form two evenly rounded lobes. Rostral prolongation of ventral dististyle, *vd*, with the two spines arising from a common tubercle, the spines longer and slenderer than in *garrula*. Mesal-apical lobe of gonapophysis, *g*, relatively stout.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 3,500 feet, July 17, 1931 (*Franck*).

Limonia (*Rhipidia*) *garruloides* is most nearly allied to *L.* (*R.*) *garrula* Alexander, likewise from western China, differing most evidently in the reduced number of antennal segments, the more extensively whitened tarsi, and the distinct wing pattern and venation.

PEDICIINI

PEDICIA (TRICYPHONA) CUBITALIS sp. nov. Plate 1, fig. 16.

General coloration of thorax gray; antennæ 13-segmented, the intermediate flagellar segments crowded, transverse; legs relatively short and stout; femora yellow, the tips narrowly blackened; wings light yellow, veins R, Cu, and the cord narrowly seamed with dark brown, forming a nearly complete discal triangle; abdomen orange, the tergites with a median black vitta, the outer segments darker.

Female.—Length, about 24 millimeters; wing, 18.5.

Rostrum gray; palpi brownish black; terminal segment short, not exceeding the penultimate. Antennæ 13-segmented; scape dark brown, the remainder of organ a trifle paler; intermediate flagellar segments short and crowded, transverse, the longest verticils unilaterally arranged, exceeding the segments; outer flagellar segments smaller and more elongate. Head gray; vertical tubercle very small.

Mesonotal præscutum light gray, with three darker gray stripes, the interspaces with yellow setæ; posterior sclerites of mesonotum darker, the caudal margin of the mediotergite slightly infumed. Pleura gray, more or less covered by yellowish pollen. Halteres pale yellow, the knobs weakly darkened. Legs relatively short and stout; coxæ and trochanters yellow; femora yellow, the tips narrowly brownish black; tibiæ brownish yellow, the tips narrowly darkened; tarsi black. Wings (Plate 1, fig. 16) with the ground color light yellow, cells C and Sc a little darker, more brownish yellow; restricted dark brown seams adjoining vein R, in cell R, extending from arculus to origin of Rs; along vein Cu; and a slightly wider seam along the cord, the three areas forming the three sides of a typical *Pedicia*-triangle, broken only between the origin of Rs and the cord; posterior prearcular region darkened; outer end of cell 1st M_2 weakly darkened; stigma yellowish brown; veins brownish yellow, darker in the infuscated areas, with extensive obliterative areas along cord. Venation: Sc_2 faint, a short distance before origin of Rs; r-m connecting with Rs before its fork; R_2 about opposite the fork of R_{4+5}; cell 1st M_2 closed; cord moderately oblique.

Abdomen with the basal tergite gray; tergites two to five orange, with a continuous median black vitta; outer segments more pruinose laterally, blackened medially; sternites orange, the outer segments darkened medially. Ovipositor with the dorsal shield and cerci blackened.

Habitat.—Japan (Honshiu).

Holotype, female, Mount Kurobegoro, Echiu, in subalpine meadow, altitude 7,800 feet, August 10, 1931 (*Imanishi*).

Pedicia (*Tricyphona*) *cubitalis* is most nearly allied to the Japanese *gaudens* (Alexander) and *grandior* (Alexander), all three species being closely related and suggesting in a striking manner the smaller species of the typical subgenus *Pedicia* Latreille. The present fly differs from the two above-mentioned species in the narrow but conspicuous dark cubital seam and the entirely flavescent central portion of the wing disk, this being

much paler than the margins in both listed species. Only the male sex of *gaudens* and *grandior* has been discovered; *gaudens* has the antennæ 13-segmented, the flagellum brownish yellow, much paler than the black scape and pedicel, and the basal abdominal tergites without a continuous black median stripe; *grandior* has only 11-segmented antennæ and has the dark wing pattern much reduced.

DICRANOTA (RHAPHIDOLABIS) SPINA sp. nov. Plate 1, fig. 17; Plate 4, fig. 48.

General coloration gray, the præscutum with three more black ish stripes; antennæ 13-segmented, black throughout; wings milky, the stigma scarcely indicated; cell R_3 nearly sessile, R_{2+3+4} being reduced to a punctiform element; male hypopygium with the median region of tergite broadly convex, each lateral arm produced into a straight acute spine; interbase a powerful flattened rod, the apex narrowed to an acute spine.

Male.—Length, about 5.5 millimeters; wing, 5.8.

Rostrum and palpi black. Antennæ 13-segmented, short, black throughout; flagellar segments oval, the verticils shorter than the segments; terminal segment smaller than the penultimate. Head gray.

Mesonotum gray, the præscutum with three ill-defined, more blackish stripes. Pleura gray. Halteres pale, the knobs slightly infuscated. Legs with the coxæ obscure yellow; trochanters yellow; femora yellow, passing into brown at about the basal third; remainder of legs brown. Wings (Plate 1, fig. 17) with a milky ground color, somewhat more grayish on outer half; stigma scarcely indicated; veins pale brown. Macrotrichia of veins short but abundant, on all veins beyond cord, M and 1st A except basal fifth, Cu except basal third, 2d A on about distal half. Venation: R_{1+2} about one-half R_2; cell R_3 nearly sessile, R_{2+3+4} indicated only by a punctiform element; m-cu more than one-half its length beyond fork of M.

Abdomen dark grayish brown; hypopygium more yellowish. Male hypopygium (Plate 4, fig. 48) with the median region of tergite, *9t*, broadly convex, with numerous erect setæ; lateral arm of tergite produced into a slender, straight, acute spine. Basistyle, *b*, with the outer apical lobe a little produced and set with rather sparse spines; interbase, *i*, a powerful, flattened rod, at about two-thirds the length gradually curved to form a right-angled, gently curved, acute spine, the surface glabrous. Outer dististyle, *od*, stout-clavate, the apex with more-abundant spines.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Kurobegoro, Echiu, in subalpine meadow, altitude 7,800 feet, August 13, 1931 (*Imanishi*).

Dicranota (*Rhaphidolabis*) *spina* is readily distinguished from the other regional species in eastern Asia by the milky white wings, with cell R_3 nearly sessile, and by the acute, straight, lateral spine of the ninth tergite of the male hypopygium.

DICRANOTA (AMALOPINA) MEGAPLAGIATA sp. nov. Plate 1, fig. 18.

Allied to *gibbera;* general coloration of thorax pale yellow, the postnotum somewhat darker; wings whitish, sparsely variegated with brown, including a major area extending from costa across anterior cord; cell 1st M_2 open by atrophy of m.

Female.—Length, about 5 millimeters; wing, 5.

Rostrum and palpi brownish black. Antennæ with the scape black; flagellum light yellow. Head grayish brown.

Mesonotum pale yellow, the postnotum somewhat darker. Pleura pale yellow. Halteres pale yellow throughout. Legs all detached; what appear to represent the forelegs have the femora and extreme bases of tibiæ brownish black; remainder of legs whitish, the outer tarsal segments darkened; one other pair of legs is present, whitish, the tips of the femora, narrower tips of tibiæ, and outer segments of tarsus darkened. Wings (Plate 1, fig. 18) whitish, with a restricted brown pattern, including a single large area extending from costa across wing to fork of M; additional small brown dots, distributed as follows: Sc_2, origin of Rs, R_2, posterior cord, marginal dots at ends of longitudinal veins, forks of M_{1+2} and M_{3+4}, and two or three small spots in cell Cu adjoining vein 1st A; veins pale, darker in the infuscated areas.

Abdominal tergites bicolorous, the apices conspicuously dark brown, the central parts of the basal rings obscure yellow, the lateral portions more darkened; sternites more extensively yellow, the caudal margins of the segments narrowly darkened.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 7,000 feet, July 17, 1931 (*Franck*).

The present fly is undoubtedly allied to *D.* (*A.*) *elegantula* (Brunetti) and *D.* (*A.*) *gibbera* (Alexander), differing from all known species by the large darkened area on the anterior cord of the wings. In *gibbera,* the fore and middle femora are darkened, while the posterior femora are chiefly pale. It seems certain that this is the condition obtaining in the present fly.

ULA SUCCINCTA sp. nov. Plate 1, fig. 19; Plate 4, fig. 49.

General coloration yellowish brown, the head dark; femora yellow, the tips vaguely darkened; wings brownish yellow, almost immaculate; stigma uniformly pale yellowish brown; abdominal tergites uniformly dark brown; basal sternites yellow.

Male.—Length, about 5.5 millimeters; wing, 5.5.

Rostrum obscure yellow, darker medially above; palpi brown, the elongate terminal segment paling to obscure yellow. Antennæ with the scape and pedicel brownish yellow; flagellum dark brown; flagellar segments (male) subcylindrical, with short, inconspicuous verticils. Head dark brown, possibly pruinose in dry specimens.

Mesonotum and pleura yellowish brown, the humeral region of præscutum obscure yellow. Halteres pale. Legs with the coxæ yellow, the fore coxæ slightly darkened at bases; trochanters yellow; femora and tibiæ obscure yellow, the tips of the former vaguely darkened; tarsi yellow, passing to brown on outer segments. Wings (Plate 1, fig. 19) brownish yellow, almost immaculate, the stigma uniformly pale yellowish brown, without distinctly darkened ends; an almost imperceptible clouding along anterior cord; veins brownish yellow.

Abdominal tergites uniformly dark brown; sternites two to five yellow. Male hypopygium (Plate 4, fig. 49) with the ninth tergite, *9t*, gradually narrowed outwardly, the caudal margin with a deep U-shaped median notch, the lateral lobes obtusely rounded at tips. Dististyle, *d*, relatively long and slender, the outer end with about fifteen black spines.

Habitat.—Japan (Honshiu).

Holotype, alcoholic male, Mount Mitake, Musashi, May 10, 1931 (*Oda*).

Ula succincta is closest to *U. cincta* Alexander (Hokkaido), which is still known to me only in the female sex. The present fly differs in the more nearly immaculate wings, with the central portion of the stigmal area concolorous with the ends, and in the uniformly darkened abdominal tergites.

HEXATOMINI

LIMNOPHILA (PRIONOLABIS) ODAI sp. nov. Plate 1, fig. 20; Plate 4, fig. 50.

Male.—Length, about 8 millimeters; wing, 7.

Female.—Length, about 10 millimeters; wing, 8.5.

Closely allied and generally similar to *submunda*, differing especially in slight details of the male hypopygium. Wings (Plate

1, fig. 20) unusually broad. Legs with the femora obscure yellow, the tips narrowly dark brown, the latter approximately equal in degree on all legs, including the fore pair, embracing (male) about the outer fourth to fifth. Male hypopygium (Plate 4, fig. 50) with the outer dististyle, *od*, bearing a single major subapical spine. Inner dististyle, *id*, with two, long, erect, subterminal spines, the apex beyond this point slender. Gonapophyses, *g*, pale throughout.

Limnophila (*Prionolabis*) *odai* is named in honor of the collector, Prof. Bunkichi Oda, who has collected numerous Tipulidæ in the vicinity of Tokyo. The only other species that is close to this fly is *L.* (*P.*) *submunda* Alexander, of Honshiu and Kyūshū.[6] The latter fly is the only described Japanese member of the subgenus with dusky gonapophyses, and presents a general appearance very different from that found in the present fly.

ERIOPTERINI

ORMOSIA MACHIDANA sp. nov. Plate 1, fig. 21; Plate 4, fig. 51.

General coloration of mesonotal præscutum dark reddish brown, with a narrow, darker brown, median vitta; posterior sclerites of mesonotum and the pleura brownish black; halteres yellow; wings with anal veins convergent; male hypopygium with the inner dististyle a slender, gently curved rod; two pairs of gonapophyses, the inner pair slightly expanded and weakly roughened at tips.

Male.—Length, about 4.5 millimeters; wing, 5.3; antenna, about 1.25.

Rostrum and palpi black. Antennæ brownish black, relatively long, as shown by the measurements; flagellar segments elongate, with verticils that exceed the segments. Head blackish.

Mesonotal præscutum dark reddish brown, with a narrow, darker brown, median vitta; humeral region obscure yellow, inclosing the blackish pseudosutural foveæ; posterior sclerites of mesonotum and the pleura brownish black, sparsely pruinose. Halteres yellow. Legs with the coxæ brown; trochanters obscure yellow; legs yellowish brown, the outer tarsal segments darker. Wings (Plate 1, fig. 21) with a brownish tinge, the stigma darker; basal portion of wing more yellowish; veins brown. Venation: Sc_2 nearly opposite midlength of Rs; cell 1st M_2 open

[6] Entomol. Mag. Kyoto 3 (1919) 125–126.

by atrophy of basal section of M_3; vein 2d A strongly sinuous, cell 1st A being widest at midlength.

Abdomen, including hypopygium, dark brown. Male hypopygium (Plate 4, fig. 51) with the tergite, *9t*, appearing as a conspicuous spatula. Outer dististyle, *od*, broad, dilated at near midlength, the apex blackened and acutely pointed. Inner dististyle a slender, gently curved rod. Gonapophyses, *g*, in two pairs, the outer pair appearing as slender blackened spines, the inner pair stouter, their apices weakly expanded and microscopically roughened.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Shirouma, Shinano, August 8, 1931 (*Machida and Nakamura*).

I take pleasure in naming this distinct *Ormosia* in honor of my old friend Dr. Jiro Machida, to whom I am deeply indebted for many kind favors in the past decade. The species is distinct from all others in eastern Asia in the structure of the male hypopygium. It comes closest to the group containing *O. takahashii* Alexander, *O. takeuchii* Alexander, and *O. tokunagai* Alexander, yet is amply distinct in the conformation of the dististyles and gonapophyses.

MOLOPHILUS PICTIFEMORATUS sp. nov. Plate 1, fig. 22.

Belongs to the *gracilis* group and subgroup; rostrum, palpi, and antennæ black; head and thorax dark brown; halteres yellow; femora brown, the tips broadly blackened, preceded by a much narrower, clear yellow ring; wings with a strong dusky tinge; vein 2d A ending before level of m-cu.

Female.—Length, about 3 millimeters; wing, 3.5.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, with long, conspicuous verticils. Head dark brown.

Mesonotum almost uniformly dark brown, the anterior lateral pretergites restrictedly obscure yellow, the posterior sclerites of notum even darker. Pleura brownish black. Halteres yellow. Legs with the femora restrictedly pale basally, passing into brown, the tips broadly and conspicuously blackened, preceded by a much narrower clear yellow ring; tibiæ dark brown, the bases narrowly yellow, the tips slightly more broadly brownish black; tarsi dark brown. Wings (Plate 1, fig. 22) with a strong dusky tinge, the prearcular region narrowly and vaguely obscure

yellow; veins pale brown, the macrotrichia darker. Venation: R_2 in approximate alignment with r-m; vein 2d A relatively short, ending just before the level of m-cu.

Abdomen brownish black, the basal sternites paler. Ovipositor with the cerci very long and only slightly upcurved.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 3,500 feet, August 16, 1931 (*Franck*).

Molophilus pictifemoratus differs from all regional species of the genus in the pattern of the legs, especially of the femora.

MOLOPHILUS NAKAMURAI sp. nov. Plate 1, fig. 23; Plate 4, fig. 52.

Belongs to the *gracilis* group and subgroup; general coloration yellow; femora with more than the outer half black, the bases yellow; tibiæ light yellow, the tips narrowly brownish black; wings relatively narrow, yellowish gray, the costal border pale yellow; male hypopygium with the dorsal lobe of basistyle with setæ to tip; two simple dististyles, one obtuse at apex, the other narrowed to an acute point.

Male.—Length, about 3.5 to 4 millimeters; wing, 4.3 to 5.

Female.—Length, about 4.5 millimeters; wing, 5.

Rostrum and palpi dark brown. Antennæ short in both sexes, if bent backward extending to shortly beyond the wing root; basal four or five segments yellow, the remainder of flagellum brown. Head gray, the genæ and occiput in cases more yellowish.

Mesonotum light orange, the lateral pretergites pale yellow; posterior sclerites of mesonotum more testaceous. Pleura testaceous-yellow. Halteres yellow. Legs with the coxæ and trochanters yellow; femora with about the basal third obscure yellow, the remainder brownish black; tibiæ abruptly pale yellow, the tips narrowly brownish black; basal segments of tarsus obscure yellow, the narrow tips of the segments darkened; outer tarsal segments dark brown. Wings (Plate 1, fig. 23) narrow, pale yellowish gray, the prearcular and costal portions clear yellow; veins pale and difficult to distinguish; trichia pale brown, those of the costal fringe light yellow. Venation: Vein 2d A long, extending nearly parallel to 1st A for most of its length.

Abdominal tergites brownish yellow, the caudal margins of segments narrowly paler; sternites and hypopygium clear yellow. Male hypopygium (Plate 4, fig. 52) with the dorsal lobe of

basistyle, *b*, moderately stout, with setæ to its tip. Outer dististyle, *od*, at apex expanded into a weak club that is microscopically spiculose. Inner dististyle, *id*, a little shorter, gradually narrowed to a needlelike point, the extreme tip pale.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Shirouma, Shinano, August 8, 1931 (*Machida and Nakamura*). Allotopotype, female. Paratopotypes, 4 males.

Molophilus nakamurai is named in honor of Mr. Toyoji Nakamura, collector of a number of rare species in the Japanese Alps. The peculiar pattern of the legs is quite distinctive of the species. The structure of the male hypopygium is much as in *M. pegasus* Alexander, but in all other respects the two flies are clearly different.

MOLOPHILUS TAKAOENSIS sp. nov. Plate 1, fig. 24; Plate 4, fig. 53.

Belongs to the *gracilis* group and subgroup; general coloration black; halteres yellow; male hypopygium with the dorsal lobe of basistyle short and obtuse; inner dististyle sinuous, bearing an acute lateral spine at about midlength.

Male.—Length, about 2.8 millimeters; wing, 3.3.

Described from a dried specimen formerly preserved in spirit.

Rostrum black; palpi brownish yellow, the terminal segment more infuscated. Antennæ (male) short, if bent backward extending to shortly beyond the wing root; scape brown, the succeeding four or five segments light yellow, the outer segments infuscated. Head black.

Mesonotum and pleura shiny black; if any bloom is normally present, it is destroyed by immersion in spirit. Halteres yellow. Legs with the fore coxæ light brownish yellow, the remaining coxæ light yellow; trochanters yellow; remainder of legs chiefly yellow, the tips of femora and tibiæ narrowly and weakly darkened; terminal tarsal segments infuscated; one detached leg, evidently one of the fore pair, has about the distal half of femora dark brown, the tibia with a pale brown subbasal ring; most of vestiture of legs is lost through immersion in spirit, but enough persists to indicate that the setæ of the yellow portions of the legs are pale in color. Wings (Plate 1, fig. 24) with a weak brown tinge; veins darker brown. Venation: R_{4+5} in general longitudinal alignment with Rs; petiole of cell M_3 about twice m-cu; vein 2d A relatively short, ending before m-cu.

Abdomen, including hypopygium, brownish black. Male hypopygium (Plate 4, fig. 53) with the dorsal lobe, *db,* of basistyle short and obtuse; mesal lobe, *mb,* darkened, densely set with numerous recurved setulæ; ventral lobe longest, with a marginal fringe of coarse setæ. Two dististyles, the outer, *od,* a slender simple rod, with appressed denticles on outer two-thirds; inner style, *id,* longer, strongly sinuous, at near midlength bearing a slender acute spine, beyond which point the surface of style is roughened into appressed teeth, the long acute apex glabrous.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Takao, Musashi, June 1, 1930 (*Oda*).

Molophilus takaoensis is most generally similar to *M. trifilatus* Alexander, differing most evidently in the very different male hypopygium.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *d*, dististyle; *db*, dorsal lobe of basistyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *mb*, mesal lobe of basistyle; *od*, outer dististyle; *s*, sternite; *t*, tergite; *vb*, ventral lobe of basistyle; *vd*, ventral dististyle.]

PLATE 1

FIG. 1. *Dolichopeza* (*Oropeza*) *inomatai* sp. nov.; venation.
2. *Macgregoromyia brevicula* sp. nov.; venation.
3. *Tipula* (*Schummelia*) *bidenticulata* sp. nov.; venation.
4. *Tipula* (*Schummelia*) *jocosipennis* sp. nov.; venation.
5. *Tipula* (*Schummelia*) *imanishii* sp. nov.; venation.
6. *Tipula* (*Acutipula*) *subturbida* sp. nov.; venation.
7. *Tipula sakaguchiana* sp. nov.; venation.
8. *Tipula quadrispicata* sp. nov.; venation.
9. *Tipula sempiterna* sp. nov.; venation.
10. *Tipula hibii* sp. nov.; venation.
11. *Tipula legalis* sp. nov.; venation.
12. *Tipula illegitima* sp. nov.; venation.
13. *Tipula pollex* sp. nov.; venation.
14. *Limonia* (*Dicranomyia*) *suspensa* sp. nov.; venation.
15. *Limonia* (*Rhipidia*) *garruloides* sp. nov.; venation.
16. *Pedicia* (*Tricyphona*) *cubitalis* sp. nov.; venation.
17. *Dicranota* (*Rhaphidolabis*) *spina* sp. nov.; venation.
18. *Dicranota* (*Amalopina*) *megaplagiata* sp. nov.; venation.
19. *Ula succincta* sp. nov.; venation.
20. *Limnophila* (*Prionolabis*) *odai* sp. nov.; venation.
21. *Ormosia machidana* sp. nov.; venation.
22. *Molophilus pictifemoratus* sp. nov.; venation.
23. *Molophilus nakamurai* sp. nov.; venation.
24. *Molophilus takaoensis* sp. nov.; venation.

PLATE 2

FIG. 25. *Dolichopeza* (*Oropeza*) *inomatai* sp. nov.; male hypopygium.
26. *Macgregoromyia brevicula* sp. nov.; male hypopygium.
27. *Tipula* (*Schummelia*) *bidenticulata* sp. nov.; male hypopygium, details.
28. *Tipula* (*Schummelia*) *jocosipennis* sp. nov.; male hypopygium, lateral aspect; ninth tergite.
29. *Tipula* (*Schummelia*) *imanishii* sp. nov.; male hypopygium, details.
30. *Tipula* (*Acutipula*) *intacta* sp. nov.; male hypopygium, details.
31. *Tipula* (*Acutipula*) *subturbida* sp. nov.; male hypopygium, inner dististyle.
32. *Tipula sakaguchiana* sp. nov.; male hypopygium, details.

PLATE 3

FIG. 33. *Tipula* (*Vestiplex*) *serridens* Alexander; male hypopygium, details.
34. *Tipula quadrispicata* sp. nov.; male hypopygium, details.
35. *Tipula tetracantha* Alexander; male hypopygium, details.
36. *Tipula curvicauda* Alexander; male hypopygium, lateral aspect.
37. *Tipula curvicauda* Alexander; male hypopygium, ninth tergite.
38. *Tipula curvicauda* Alexander; male hypopygium, outer dististyle.
39. *Tipula curvicauda* Alexander; male hypopygium, inner dististyle.
40. *Tipula sempiterna* sp. nov.; male hypopygium, details.
41. *Tipula sempiterna* sp. nov.; male hypopygium, details.
42. *Tipula legalis* sp. nov.; male hypopygium, details.

PLATE 4

FIG. 43. *Tipula trupheoneura* Alexander; male hypopygium, details.
44. *Tipula pollex* sp. nov.; male hypopygium, details.
45. *Tipula seticellula longiligula* subsp. nov.; male hypopygium, eighth sternite.
46. *Limonia* (*Dicranomyia*) *suspensa* sp. nov.; male hypopygium.
47. *Limonia* (*Rhipidia*) *garruloides* sp. nov.; male hypopygium.
48. *Dicranota* (*Rhaphidolabis*) *spina* sp. nov.; male hypopygium.
49. *Ula succincta* sp. nov.; male hypopygium.
50. *Limnophila* (*Prionolabis*) *odai* sp. nov.; male hypopygium.
51. *Ormosia machidana* sp. nov.; male hypopygium.
52. *Molophilus nakamurai* sp. nov.; male hypopygium.
53. *Molophilus takaoensis* sp. nov.; male hypopygium.

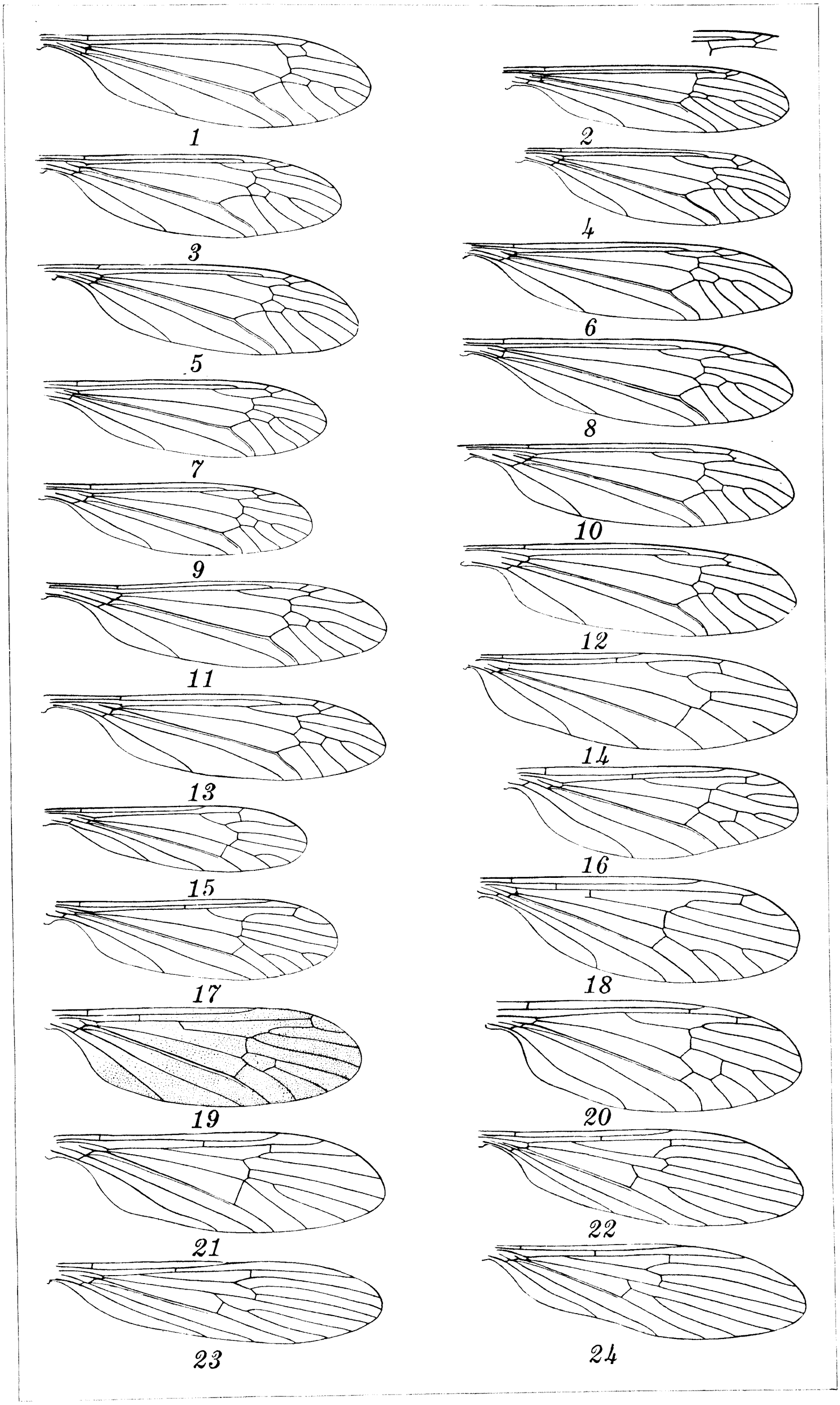

PLATE 1.

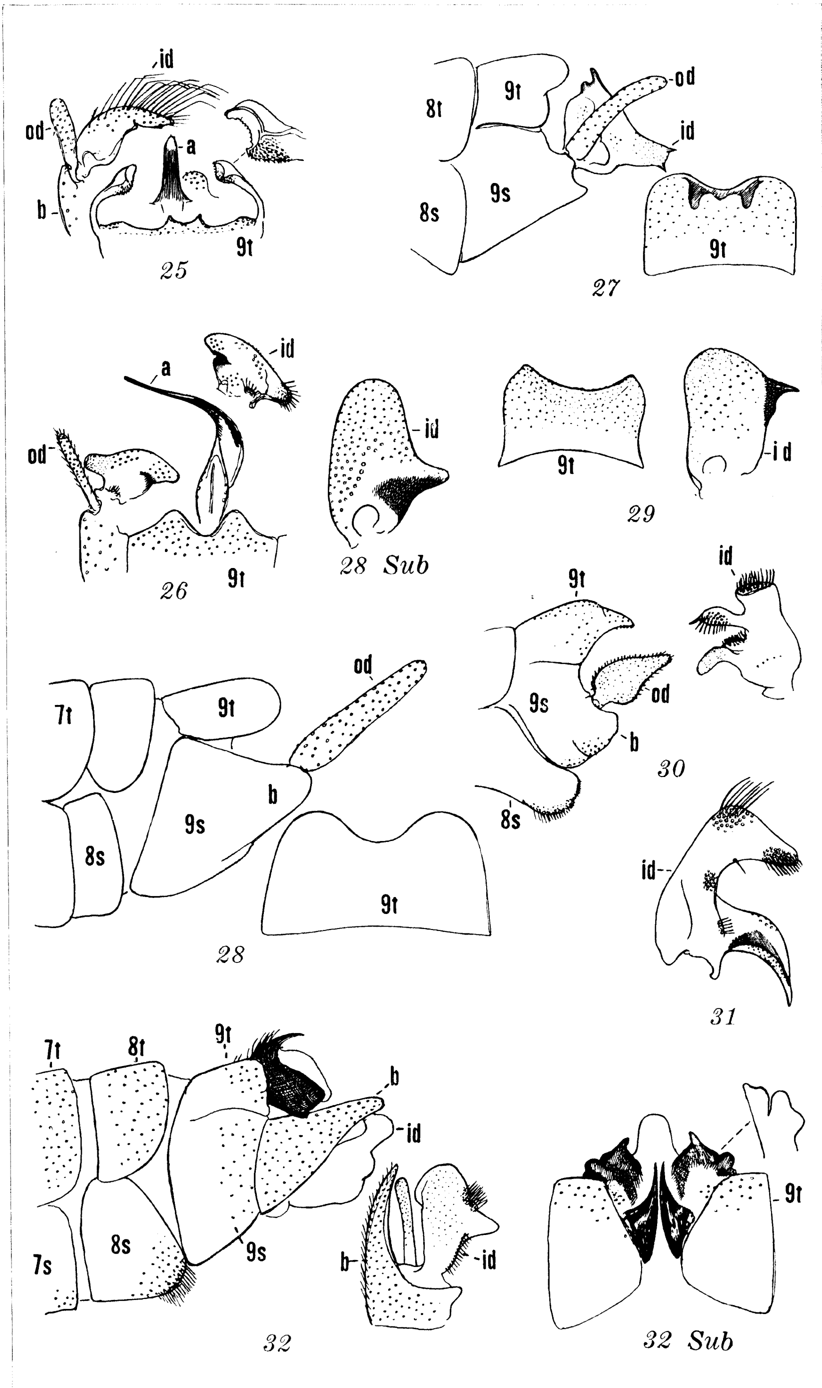
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PLATE 2.

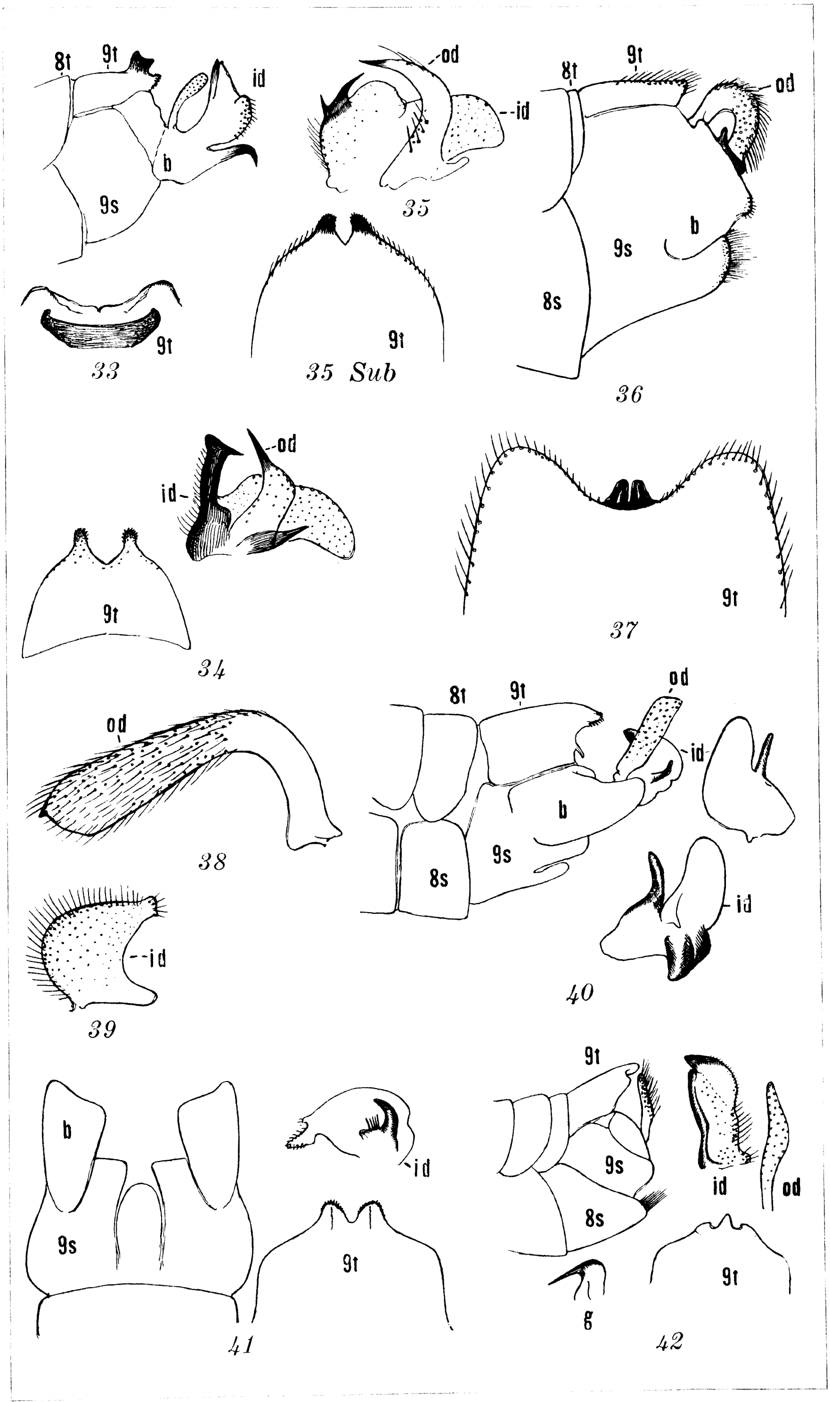
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PLATE 3.

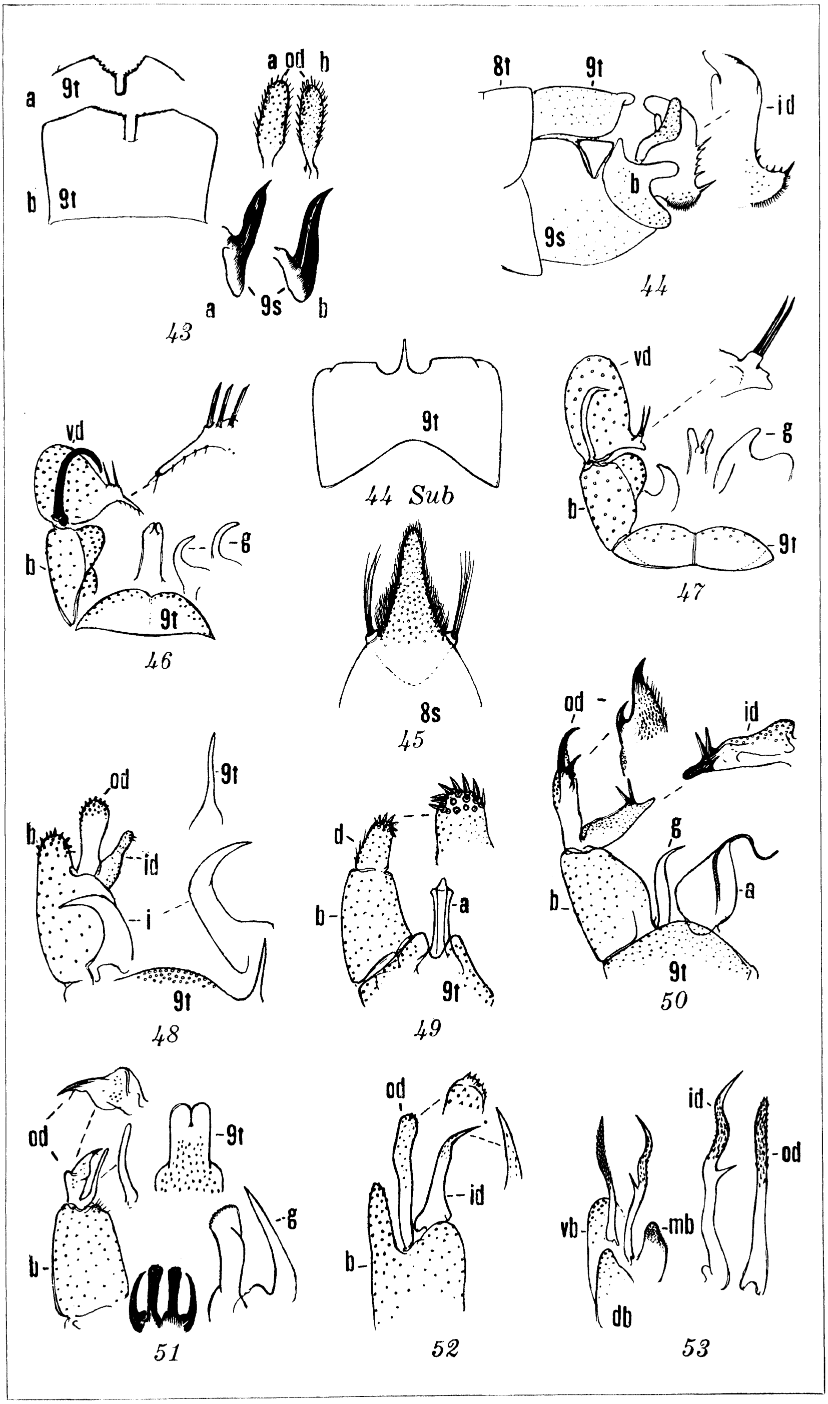
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PLATE 4.

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DURATION OF THE SEROLOGIC REACTIONS IN MONKEYS INOCULATED WITH YAWS OR SYPHILIS

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It has been determined in previous experiments that the serologic picture in experimental yaws and syphilis[1] consists of two phases. The early serologic reaction coincides with the formation of a primary lesion and disappears at the time when this heals. The late serologic response has been demonstrated in animals that developed only primary lesions; it appeared about six months after inoculation and coincided with the resistance to superinoculation.[2] The effect of specific treatment on the early serologic response has also been ascertained. Animals that gave positive results before treatment were repeatedly examined and found negative.[3]

The duration of the early as well as the late serologic reaction has been studied in this laboratory up to a certain limit of time. The present investigation is concerned with the study of the duration of the late serologic reaction beyond the time limit previously tested. It also shows the result of experiment on the effect of specific treatment with neosalvarsan on the late serologic reaction.

PAST HISTORY OF THE ANIMALS USED

The monkeys employed in this experiment represent groups of animals that were used for the study of immunity conferred by either single infection or reënforced by vaccination or super-

[1] Philip. Journ. Sci. 42 (1930) 205, 206, and 210.
[2] Philip. Journ. Sci. 42 (1930) 211.
[3] Philip. Journ. Sci. 35 (1928) 292.

inoculation. After being treated with neosalvarsan some of these animals were reinoculated with yaws alone or with both yaws and syphilis. The history of each individual monkey may be consulted in the accompanying tables. Tables 1, 2, and 3 show the dates, number, and kind of inoculations received by each monkey, while Tables 4, 5, and 6 show the period of time that elapsed between the first inoculation and the last serologic tests, Wassermann [4] and Kahn,[5] performed on each animal. Table 7 shows the group of animals that were treated at the early and late stages of infection.

DISCUSSION OF RESULTS

As may be seen from the results of the Wassermann and Kahn tests given in Tables 1, 2, and 3, the animals, with very few exceptions, showed a rather strong serologic response. The Kahn test, which was not repeated, was negative with monkeys O–c–1, O–C–2, L–13, Sy–G–22, and Sy–P–23. However, the results of the Wassermann test with the same animals were markedly positive. The animals did not show any external lesions at the time of collecting blood.

Variations in the strength of the serologic reactions were found in the treated animals, in some of which the serologic reaction was either stationary, very low, or very sluggish before it became entirely negative.[6] The animals J–11, T–4, W–25, and W–27, which received treatment during their high resistance—that is, late after inoculation—continued to show rather strong serologic reactions at the time of examination, while in monkeys K–25, K–26, K–27, and K–28, which were treated in the early stage of infection, the degree of serologic reactions was entirely individual. Besides, a degree of sensitization was more profound in the first group than in the latter group of monkeys (see Table 7). This finding agrees with clinical experience, which has shown that the effect of treatment upon serologic reactions is more evident when such treatment is given in an early stage of syphilis than when given in a late stage of infection. It was also ascertained in previous experiments [7] that the Wassermann reaction, if it has become negative due to treatment or spontaneous healing, and if all the lesions have disappeared,

[4] Philip. Journ. Sci. § B 12 (1917) 249.
[5] The Kahn Test, a Practical Guide. Williams and Wilkins Co. (1928).
[6] Philip. Journ. Sci. 35 (1928) 311.
[7] Philip. Journ. Sci. 35 (1928) 261; 40 (1929) 53.

will reappear upon unsuccessful superinfection or reinoculation with killed or viable material.[8]

CONCLUSION

The results obtained in the late serologic reactions of the experimental monkeys studied herewith confirm the views regarding sensitization caused by the inoculations of killed or living treponema. The strength of the serologic reaction depends on the degree of sensitization of the tissue as influenced by the extension and duration of lesions or by frequent inoculations. The degree of the serologic reaction, however, is modified by specific treatment.

ACKNOWLEDGMENT

I wish to express my sincere appreciation to my chief, Dr. Otto Schöbl, for supplying materials for study.

[8] Philip. Journ. Sci. **35** (1928) 291–311; **42** (1930) 203–211.

TABLE 1.—*Showing the duration of Wassermann and Kahn tests in untreated and treated monkeys injected with syphilis and yaws.*

Monkey.	Syphilis.			Lymph-gland transplant.		Yaws.		
	Date.	Site of inoculation.	Result.	Date.	Result.	Date.	Site of inoculation.	Result.
J-11	IX-13-28	Intradermal	+	XI-16-28	—	III-19-26	Intradermal	+
						VII- 6-26	do	+
						IX-29-26	do	—
						IV- 4-27	do	—
						III-26-28	do	—
J-11	I- 7-30	Test for immunity	—			I-11-29	do	—
T-4	IX-13-28	Intradermal	—	XI-16-28	—	VII- 2-26	Intradermal	+
						VIII-20-26	do	+
						III- 8-27	do	
						III-26-28	do	—
T-4	I- 7-30	Test for immunity	—			I- 8-29	do	—
U-1						VII-27-27 VII-30-27 VIII- 3-27	Subcutaneous yaws 60° C.	
U-1						IX-17-27 III- 9-28 IV-23-28	Test for immunity to yaws	—
U-1	I- 7-29	Intradermal immunity test	—	0	0	II-14-30	Last test for immunity to yaws	—
W-25						I-20-28	Subcutaneous yaws 60° C.	
						I-31-28	do	
W-25						II-27-28 V- 3-28 VI-25-28	Test for immunity to yaws	—

W-25	I- 7-29	Intradermal immunity test	—	IV-26-29	+	IX-17-28	Reinfection	—
						X-22-28	do	—
						I- 7-29	do	—
						II-14-30	Immunity test	—
W-23						I-18-28	Subcutaneous yaws 60° C.	
						I-31-28		
						II- 8-28		
W-23						II-27-28	Test for immunity to yaws	—
						IV-23-28		
						VI- 4-28		
W-23	I- 7-29	Intradermal immunity test	—	V-13-29	+	IX-17-28	Reinfection	—
						X-22-28	do	
						I- 7-29	do	—
						II-14-30	Immunity test	—
W-27						I-20-28	Subcutaneous yaws 60° C.	
						I-31-28		
W-27						II-27-28	Test for immunity to yaws	—
						V- 3-28		
						VI-25-28		
W-27	I- 7-29	Intradermal immunity test	—	0	0	IX-17-28	Reinfection	—
						X-22-28	do	—
						I- 7-29	do	—
						II-14-30	Immunity test	—
E-41	VI-22-29	Intradermal	—	IX-11-29	—	II- 1-28	Vaccination 60° C.	
						II-28-28	Intradermal	+
						II-27-29	Superinoculation	—
Sy-3	VI-13-28	Intradermal	+	IX- 8-28	+	IX-11-28	Intradermal	+
	I- 7-30	Immunity test	—					
Sy-5	VI-15-28	Intradermal	+	X-22-28	+	XI-13-28	do	+
	I- 7-30	Immunity test	—					
J-1	VI-22-29	Intradermal	—	IX-26-29	—	VIII-17-28	Intradermal	+
						II-27-29	Test for immunity	—

TABLE 1.—*Showing the duration of Wassermann and Kahn tests in untreated and treated monkeys injected with syphilis and yaws*—Continued.

Monkey.	Syphilis.			Lymph-gland transplant.		Yaws.		
	Date.	Site of inoculation.	Result.	Date.	Result.	Date.	Site of inoculation.	Result.
Sy-G-22	VI-22-29	Intradermal	+	X- 4-29	+	X-14-29	Intradermal	+
	VIII-14-29	do	—			X-21-29	Superinfection	+
	IX-27-29	Test for immunity	—			XII- 2-29	do	+
						I- 6-30	do	+
						II-26-30	do	—
Sy-G-20	II- 5-29	Intradermal	+					
Sy-G-20	V-29-29	do	—			X- 8-29	Intradermal	—
	IX-27-29	Test for immunity	—			XII- 2-29	Superinfection	—
Sy-J-20	II- 9-29	Intradermal	+			X- 8-29	Intradermal	—
						XII- 2-29	do	—
Sy-J-20	I- 7-30	Test for immunity	—					
Sy-I-11	III-20-29	Intradermal	+			IX-21-29	Intradermal	+
	VIII-14-29	do	—			X-21-29	do	+
Sy-I-11						I- 6-30	Superinfection	—
						II-26-30	do	—
O-c-1	V-27-29	do	+			III-21-29	Intradermal	+
						VII-17-29	Superinoculation	—
						VIII-16-29	do	—
O-c-2	V-27-29	do	+			III-21-29	Intradermal	+
						VII-17-29	Superinoculation	—
						VIII-16-29	do	—
L-13	V-27-29	do	+			III- 4-29	Intradermal	+
						VII-17-29	Superinoculation	—
						VIII-16-29	do	—

Sy-P-23	VIII-14-29	do	+		X-14-29	Intradermal	+
	IX-27-29	do	—		X-21-29	do	+
					I- 6-30	Superinfection	+
					II-26-30		—
Yac-10	IX	do	—		VII- 9-29	Intradermal	+
					VIII-28-29	Superinfection	—
K-25	II-13-30				XI-27-29	Intradermal	+
	II-25-30	Vaccination 60° C.			III-27-30	do	—
	III- 4-30				V-20-30	do	—
K-26	II-13-30				XI-27-29	Intradermal	+
	II-25-30	do			III-27-30	do	—
	III- 8-30				V-20-30	do	—

TABLE 1.—*Showing the duration of Wassermann and Kahn tests in untreated and treated monkeys injected with syphilis and yaws*—Continued.

Monkey.	Neosalvarsan treatment.		Last test for Wassermann and Kahn reactions.			Test for duration.					
						Wassermann.				Kahn.	
	Date.	Dose.	Date.	Wassermann (average).	Kahn (average).	Date.	Alcohol.	Control.	Cholest.	0.025	0.0125
		g.									
J-11	XII- 2-26	0.09									
J-11						VIII- 6-30	++++	−	++++	+	++++
T-4	I-25-27 to XII-14-27	0.155									
T-4						X-25-30	++++	−	++++	++	++
U-1											
U-1											
U-1						VI-27-30	+++	−	++++	++++	++++
W-25				+							
W-25	VIII- 3-28 to	0.18		++++							
W-25	XII-14-28	0.01				VI-27-30	++++	−	++++	++++	++++
W-23				+							
				−							
W-23	VIII- 3-28	0.18		+++							
W-23	XII-14-28	0.01				VI-27-30	±	−	++++	+++	++++
W-27				+							
W-27	VIII- 3-28	0.18		++++							
W-27	XII-14-28	0.01				VI-27-30	−	−	+++	++++	++++

			4th week	—							
E-41			After infected.	+		VII- 7-30	++++	—	++++	++++	++++
Sy-3			The Wassermann and Kahn reactions were irregular up to the 57th week, becoming strongly 4+ up to the 66th week and the 69th week.			VI-24-30	—	—	++++	—	+++
Sy-5						VI-24-30	+	—	++++	++	++++
J-1						VIII- 6-30	++++	—	++++	++	++++
Sy-G-22						VII-11-30	—	—	+	—	—
Sy-G-20			Wassermann and Kahn were negative during 39 weeks' observation.								
Sy-G-20						VII-11-30	++	—	++++	++++	++++
Sy-J-20						VII-16-30	±	—	++++	—	++
Sy-I-11											
Sy-I-11						VII-11-30	±	—	++++	+	++++
O-c-1						VII-25-30	++++	—	++++	—	—
O-c-2						VII-25-30	—	—	++++	—	—
L-13						VII-23-30	±	—	++++	—	—
Sy-P-23						VII-25-30	++++	—	++++	—	—
Yac-10						VII- 1-30	—	—	++++	+	++++
K-25	I-21-30 I-27-30	0.03	6th week 8th week 11th week 14th week 16th week	+ ++ ± ± ++	— + — — —	VIII- 9-30	—	—	±	—	—
K-26	I-21-30 I-27-30	0.03	6th week 8th week 11th week 14th week 16th week	+ ++ + ++++ +++	— + — — —	VIII- 9-30	—	—	±	—	—

TABLE 2.—*Showing the duration of Wassermann and Kahn tests in untreated and treated monkeys injected with yaws alone.*

Monkey.	Syphilis.			Lymph-gland transplant.		Yaws.		
	Date.	Site of inoculation.	Result.	Date.	Result.	Date.	Site of inoculation.	Result.
J-18						IV-16-28	Vaccination 100° C.	
						VI-26-28	Intradermal	+
						II-27-29	Superinoculation	—
f-2						VI-25-28	Intradermal	+
						II-27-29	Superinoculation	—
Monkey No. 1, Guzon strain						X-15-28	Intradermal	+
						I-26-29	Autosuperinoculation on both eyebrows	?
Z-1						VIII- 2-28	Inflammatory skin tissues from yaws monkeys	
							Intradermal	Yaw
L-15						IV- 8-29		
						VI-18-29	Superinoculation	—
						VII-11-29	do	—
Y-G-25						X- 8-29	Intradermal	+
K-12						V-10-29	do	—
						VII-11-29	do	—
K-13						V-10-29	do	+
F-38						VI-29-29	do	+
YB-9						VII-17-29	do	+
						VIII-16-29	do	+
YM-20						IX-21-29	do	+
						X-21-29	do	+
K-27						XI-27-29	do	?
						III-27-30	do	+
K-28						XI-27-29	do	+
						III-27-30	do	+

TABLE 2.—*Showing the duration of Wassermann and Kahn tests in untreated and treated monkeys injected with yaws alone*—Continued.

Monkey.	Neosalvarsan treatment.		Last test for Wassermann and Kahn reactions.			Test for duration.					
							Wassermann.			Kahn.	
	Date.	Doses.	Date.	Wassermann (average).	Kahn (average).	Date.	Alcohol.	Control.	Cholest.	0.025	0.0125
J-18			V-17-28	++++	+++						
						X-25-30	++++	—	++++	+++	++
f-2						VIII- 6-30	++++	—	++++	++++	++++
Monkey No. 1, Guzon strain						XI- 7-30	—	—	—	—	—
Z-1			VI-20-28	—							
			VII- 5-28	—							
			IX- 3-28	—							
			IX-13-28	—							
			IX-27-28	—							
			X- 9-28	—							
			X-30-28	—							
			XI-14-28	±							
			XII- 7-28	—		V-25-30	++++	—	++++	++	++
I-15						VII-23-30	+++	—	++++	+++	++++
Y-G-25						VIII- 8-30	++++	—	++++	++++	++++
K-12			VIII-12-29	Microscopically positive for spirochete.		VII-16-30	+	—	++++	++	++++
K-13						VII-16-30	++++	—	++++	—	++++
F-38						VII- 7-30	—	—	++++	—	++
YB-9						VII- 1-30	++++	—	++++	++++	++++
YM-20						VII-23-30	—	—	++++	—	++++

TABLE 2.—*Showing the duration of Wassermann and Kahn tests in untreated and treated monkeys injected with yaws alone*—Continued.

Monkey.	Neosalvarsan treatment.		Last test for Wassermann and Kahn reactions.			Test for duration					
							Wassermann.			Kahn.	
	Date.	Doses.	Date.	Wassermann (average).	Kahn (average).	Date.	Alcohol.	Control.	Cholest.	0.025	0.0125
K-27	I-21-30, I-27-30	0.03	6th week	++	±	------	------	------	------	------	------
			8th week	++++	+	------	------	------	------	------	------
			11th week	—	—	------	------	------	------	------	------
			14th week	+++	—	------	------	------	------	------	------
			16th week	+	—	VIII- 9-30	—	—	+	—	—
K-28	I-21-30, I-27-30	0.03	6th week	+	—	------	------	------	------	------	------
			8th week	+++	++	------	------	------	------	------	------
			11th week	±	—	------	------	------	------	------	------
			14th week	++	—	------	------	------	------	------	------
			16th week	+++	—	VIII- 9-30	—	—	++++	—	++++

TABLE 3.—*Showing the duration of Wassermann and Kahn tests in untreated monkeys injected with syphilis alone.*

Monkey.	Syphilis.			Lymph-gland transplant.		Yaws.		
	Date.	Site of inoculation.	Result.	Date.	Result.	Date.	Site of inoculation.	Result.
Sy-D-20	V-27-29	Intradermal	+					
Sy-P-25	IX-27-29	do	+					

Monkey.	Neosalvarsan treatment.		Last test for Wassermann and Kahn.			Test for duration.					
							Wassermann.			Kahn.	
	Date.	Doses.	Date.	Wassermann (average).	Kahn (average).	Date.	Alcohol.	Control.	Cholest.	0.025	0.0125
Sy-D-20						VII-7-30	—	—	++++	—	++++
Sy-P-25						VIII-8-30	—	—	—	—	—

TABLE 4.—*Showing the duration of Wassermann and Kahn tests in untreated monkeys that were injected with both yaws and syphilis.*

Monkey.	Period between first injection and last test for duration of Wassermann and Kahn tests.		Number and kinds of inoculations.				Wassermann.			Kahn.	
			Alive.		Killed at 60° C.						
			Syphilis.	Yaws.	Syphilis vaccine.	Yaws vaccine.	Alcohol.	Control.	Cholest.	0.025	0.0125
	Yrs.	*mos.*									
U-1	3	0	1	4	0	3	++++	—	++++	++++	++++
E-41	2	5	1	2	0	1	++++	—	++++	++++	++++
Sy-3	2	0	2	1	0	0	—	—	++++	—	+++
Sy-5	2	0	2	1	0	0	+	—	++++	++	++++
J-1	1	9	1	2	0	0	++++	—	++++	++	++++
Sy-G-22	1	6	2	5	0	0	—	—	+	—	—
Sy-G-20	1	5	3	2	0	0	++	—	++++	++++	++++
Sy-J-20	1	5	2	2	0	0	±	—	++++	—	++
Sy-I-11	1	4	2	4	0	0	±	—	++++	+	++++
L-13	1	4	1	3	0	0	±	—	++++	—	—
O-c-1	1	4	1	3	0	0	++++	—	++++	—	—
O-c-2	1	4	1	3	0	0	—	—	++++	—	—
Sy-P-23	0	9	2	4	0	0	++++	—	++++	—	—
Yac-10	0	9	1	2	0	0	—	—	++++	±	++++

TABLE 5.—*Showing the duration of Wassermann and Kahn tests in untreated monkeys that were injected with yaws only.*

Monkey.	Period between first injection and last test for duration of Wassermann and Kahn tests.		Number and kinds of inoculations.				Wassermann.			Kahn.	
			Alive.		Killed at 60° C.						
			Syphilis.	Yaws.	Syphilis vaccine.	Yaws vaccine.	Alcohol.	Control.	Cholest.	0.025	0.0125
	Yrs.	*mos.*									
J-18	2	4	0	2	0	1	++++	—	++++	+++	++
f-2	2	1	0	2	0	0	++++	—	++++	++++	++++
No. 1	2	0	0	2	0	0	—	—	—	—	—
Z-1	1	7	0	1	0	(a)	++++	—	++++	++	++
Y-G-25	1	3	0	1	0	0	++++	—	++++	++++	++++
L-15	1	3	0	3	0	0	+++	—	++++	++++	++++
K-12	1	2	0	2	0	0	+	—	++++	++	++++
K-13	1	2	0	1	0	0	++++	—	++++	—	++++
F-38	1	0	0	1	0	0	—	—	++++	—	++
YB-9	0	10	0	2	0	0	++++	—	++++	++++	++++
YM-20	0	8	0	2	0	0	—	—	++++	—	++++

[a] Tissue from yaws.

TABLE 6.—*Showing the duration of Wassermann and Kahn tests in untreated monkeys that were injected with syphilis only.*

Monkey.	Period between first injection and last test for duration of Wassermann and Kanh tests.		Number and kinds of inoculations.				Wassermann			Kahn.	
			Alive.		Killed at 60° C.						
			Syphilis.	Yaws.	Syphilis. vaccine.	Yaws vaccine.	Alcohol.	Control	Cholest.	0.025	0.0125
	Yr.	*mos.*									
Sy-D-20	1	1	1	0	0	0	—	—	++++	—	++++
Sy-P-25	0	9	1	0	0	0	—	—	—	—	—

TABLE 7.—*Showing the duration of Wassermann and Kahn tests in treated monkeys that were inoculated twice or more with either yaws alone or both syphilis and yaws.*

Monkey.	Duration between first infection and last Wassermann and Kahn tests.		Number and kinds of inoculations.					Wassermann.			Kahn.	
			Syphilis.	Yaws.	Yaws vaccine.	Syphilis vaccine.	Neo-salvarsan treatment.	Alcohol.	Control.	Cholest.	0.025	0.0125
	Yrs.	*mos.*										
J-11	4	5	2	6	0	0	0.09	++++	—	++++	+	++++
T-4	4	2	2	5	0	0	0.155	++++	—	++++	++	++
W-23	2	5	1	7	3	0	0.19	±	—	++++	+++	++++
W-25	2	5	1	7	2	0	0.19	++++	—	++++	++++	++++
W-27	2	5	1	7	2	0	0.19	—	—	++++	++++	++++
K-25	0	7	0	3	0	3	0.03	—	—	±	—	—
K-26	0	7	0	3	0	3	0.03	—	—	±	—	—
K-27	0	7	0	2	0	0	0.03	—	—	±	—	—
K-28	0	7	0	2	0	0	0.03	—	—	++++	—	++++

THE EFFECT OF NEOSALVARSAN TREATMENT ON THE LATE SEROLOGIC REACTIONS OF PHILIPPINE MONKEYS INOCULATED WITH YAWS OR BOTH YAWS AND SYPHILIS.

By ONOFRE GARCIA

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THREE TEXT FIGURES

The early serologic reaction produced by a primary treponematous lesion is more amenable to treatment than the late one that coincides with the development of full immunity.[1] Monkeys that become serologically negative following treatment may again become serologically positive after reinoculation with either killed or living yaws or syphilis treponema.[2] The duration of the late serologic reaction in Philippine monkeys has been determined in the previous report.[3]

The present experiment has the purpose of studying the effect of the neosalvarsan treatment on some animals that still show strong, positive, late serologic response beyond the limit of time previously tested.

TECHNIC OF STUDY

The history of each monkey is summarized in Table 1. The blood for the serologic reaction was withdrawn through the heart, and the treatment was given intramuscularly. In the beginning of the experiment two treatments were given within two weeks and two successive serologic reactions were performed in the following two weeks. This procedure was, however, altered when the animals showed signs of toxicity and emaciation [4] in which case the bleeding and treatment were made on the same day, and at less-regular intervals as the treatment advanced. The doses, the interval of injections, and the total amount of

[1] Philip. Journ. Sci. **35** (1928) 294.
[2] Philip. Journ. Sci. **35** (1928) 291–311; **42** (1930) 203–211.
[3] Antea.
[4] Philip. Journ. Sci. **35** (1928) 292.

drug received by each monkey are recorded in the accompanying charts (see text figures).

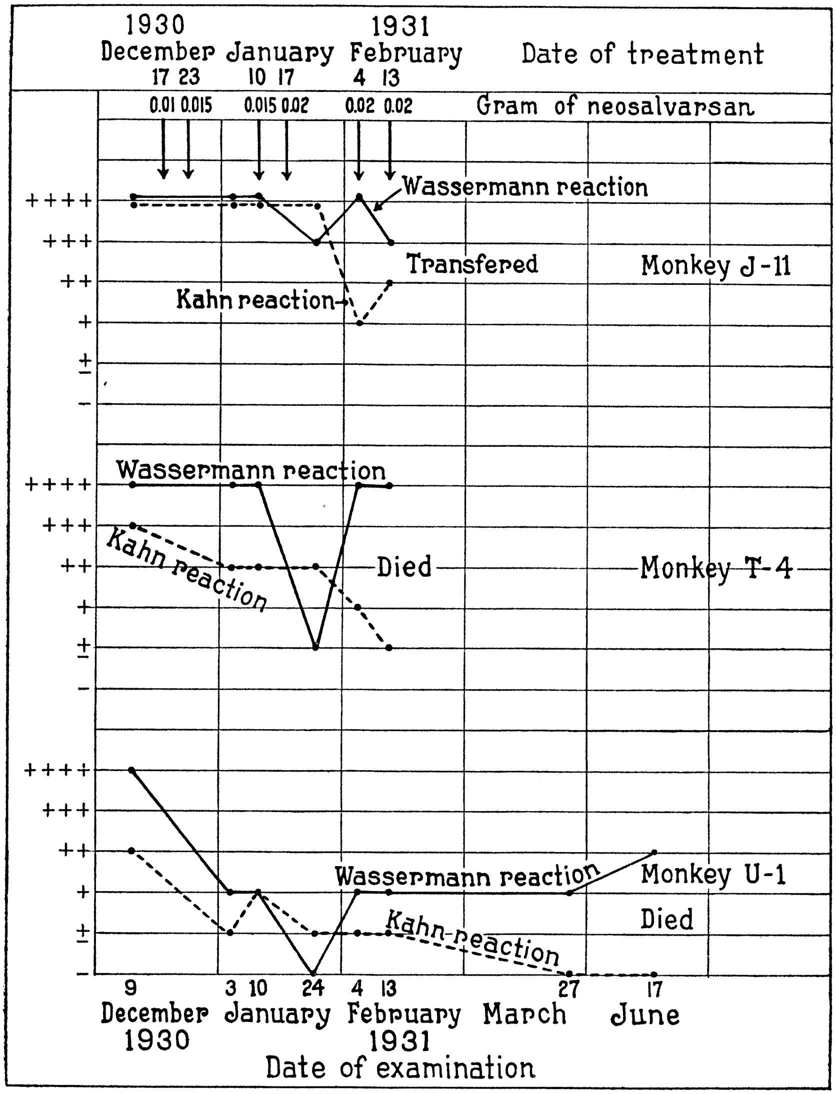

FIG. 1. Charts of monkeys J-11, T-4, and U-1.

The technics for the Wassermann [5] and Kahn [6] tests were the same as in the previous experiments.

[5] Philip. Journ. Sci. § B 12 (1917) 249; 40 (1929) 57.
[6] The Kahn Test, a Practical Guide. Williams and Wilkins Co. (1928).

TABLE 1.—*Showing the number and kinds of injections, period of inoculation or infection, and previous treatment received by the experimental monkeys.*

Monkey.	Duration of infection before treatment.		Number and kinds of inoculations.				Previous treatment with neosalvarsan.		Date of first and last inoculation.	
			Living.		Killed at 60° C. and above.					
			Syphilis.	Yaws.	Syphilis.	Yaws.	Date.	Dose.	First.	Last.
	Yrs.	*mos.*								
W-23	2	5	1	7	0	3	VIII- 3-28 XII-14-28	0.19	I-18-29	II-14-30
W-25	2	5	1	7	0	2	VIII- 3-28 XII-14-28	0.19	I-20-28	II-14-30
J-18	2	4	0	2	0	1			IV-16-28	II-27-29
f-2	2	1	0	2	0	0			VI-25-28	II-27-29
J-11	4	5	2	6	0	0	XII- 2-26	0.09	III- 9-26	I- 7-30
T-4	4	2	2	5	0	0	1-25-27 XII-14-27	0.115	VII- 2-26	I- 7-30
U-1	3	0	1	4	0	3			VII-27-27	II-14-30
j-1	1	9	1	2	0	0			VIII-17-28	VI-22-29
Z-1	1	7	0	1	0	(a)			(b)	VIII- 2-28
K-28	0	7	0	2	0	0	I-21-30 I-28-30	0.03	XI-27-29	III-27-30

[a] Tissue from yaws.

[b] Tissue from yaws; date unknown.

DISCUSSION OF RESULTS

The ten monkeys that were employed in this experiment received more than one inoculation of either yaws or both yaws and syphilis. The duration of the infection was from seven months to over four years. Five of the ten monkeys had neosalvarsan

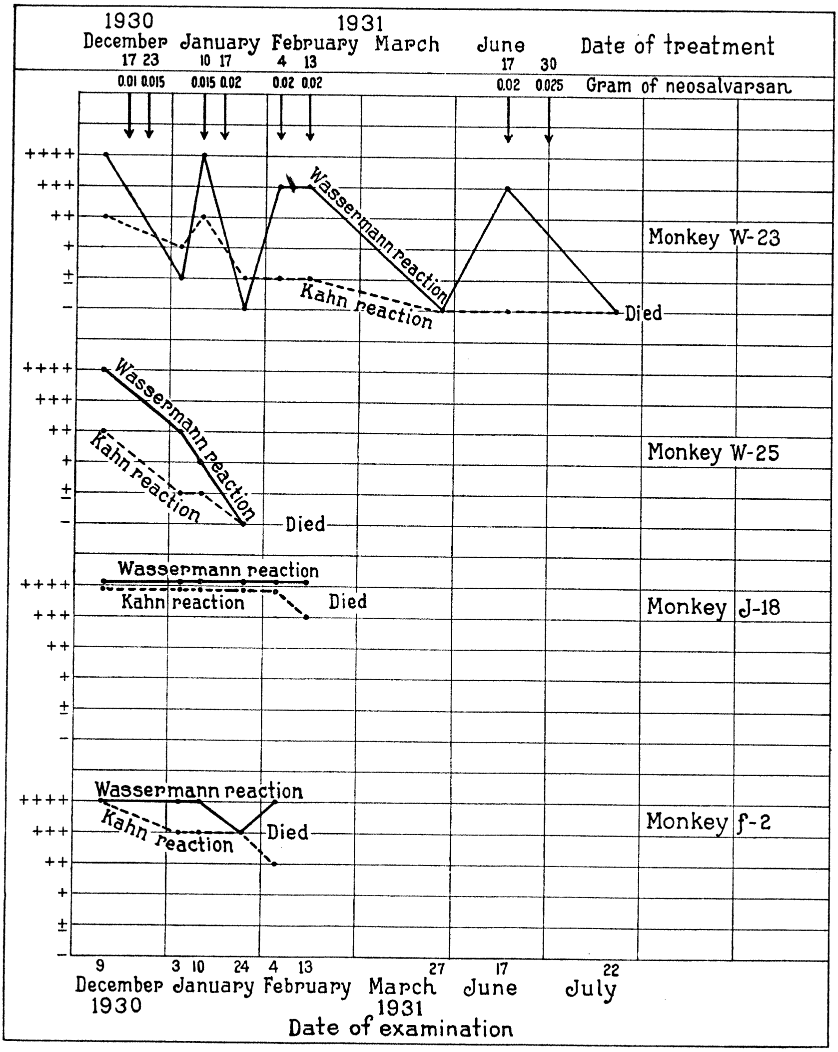

FIG. 2. Charts of monkeys W-23, W-25, J-18, and f-2.

treatment previous to this experiment, and the other five had none. Those that had received previous treatment were, however, reinoculated with yaws and syphilis. Table 2 shows the date, amount of treatment, and the serologic reactions performed before and after the last treatment.

The result of the experiment, as hereby reported, shows that monkeys W–23, W–25, and K–28, which received neosalvarsan previous to the present experiment, responded rather more promptly to treatment than those that did not receive any; monkeys K–28 and Z–1 were the only two animals that survived the nine months' treatment. These two animals presented, however, a different serologic response. Monkey K–28, which received previous treatment, responded to the last treatment sooner than

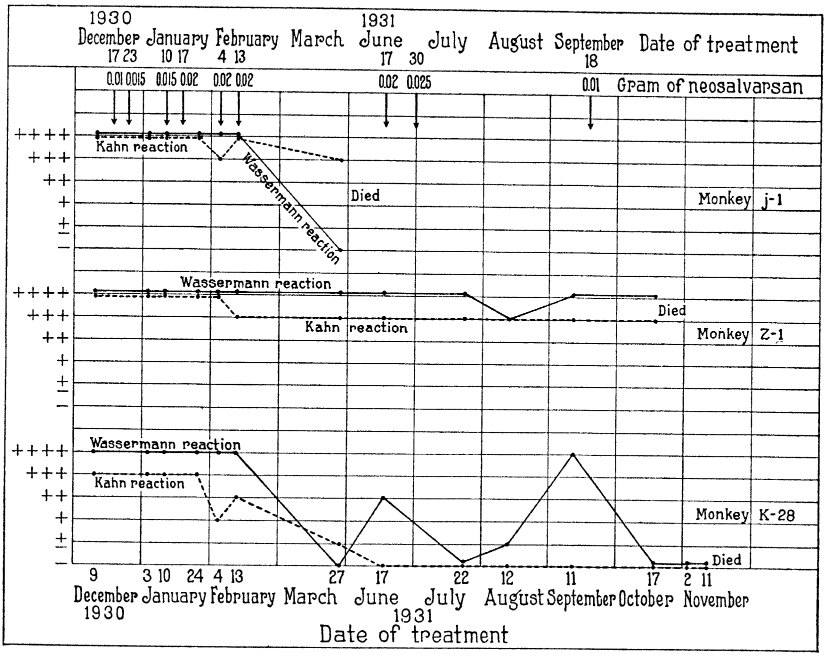

FIG. 3. Charts of monkeys j–1, Z–1, and K–28.

monkey Z–1, which did not receive any. Besides that the period of infection was longer in the latter than in the former (see text figures and Table 2). Monkeys J–18, f–2, u–1, and j–1, which were not previously treated, did not show any remarkable decrease in their serologic reactivity for the period of two to six months of treatment. However, a slight decrease or complete negative serologic reactions were noted in each monkey of the last group in either the Wassermann or the Kahn test. Although monkeys J–11 and T–4 had received previous treatment, the period of infection was extended more in these two animals than in the others and a decrease of serologic reactivity was noted within a period of three months' treatment (see Table 2 and text figures).

TABLE 2.—*Showing the duration of treatment and serologic reaction before and after treatment.*

Monkey.	Duration of infection.		Previous treatment.		Serologic reaction. Before treatment.	
			Year.	Amount.	Wassermann.	Kahn.
	Yrs.	*mos.*				
W-23	2	5	1928	0.19	++++	++
W-25	2	5	1928	0.19	++++	++
J-18	2	4	----	----	++++	++++
f-2	2	1	----	----	++++	++++
J-11	4	5	1926	0.09	++++	++++
T-4	4	2	1927	0.115	++++	+++
U-1	3	0	----	----	++++	++
j-1	1	9	----	----	++++	++++
Z-1	1	7	----	----	++++	++++
K-28	0	7	1930	0.03	++++	+++

Monkey.	After last treatment.		Inoculations received by each monkey.	Duration of treatment.	Remark.
	Wassermann.	Kahn.			
				Months.	
W-23	—	—	11	6	
W-25	—	—	10	2	
J-18	++++	+++	3	2	
f-2	++++	++	2	3	
J-11	+++	++	8	3	Transferred to rat-bite experiment.
T-4	++++	+	7	3	
U-1	++	—	8	3	
j-1	—	+++	3	3	
Z-1	++++	+++	2	9	
K-28	—	—	2	9	

Of the ten monkeys that were studied, only two survived for as long as nine months. Most of the animals died after about the third, fourth, or sixth month, beginning from the first treatment. The high susceptibility of Philippine monkeys to neosalvarsan and the frequent bleedings made on them may have been responsible for their early death. It may be seen in the text figures that the treatment was not regular, due to the fact that the animals that lived more than three months were becoming emaciated and weak.

It became known in previous experiments that the effect of the treatment on the late serologic reaction depends in general on the degree of sensitization resulting from the severity of the

infection, superinfection, or superinoculation and of individual serologic reactivity.[7] These animals that responded to the treatment as shown in the accompanying charts presented irregular curves, which are especially noted with the Wassermann test that was plotted by the reading of the cholesterolized antigen alone. The Kahn test was recorded by the average reading of three tubes.

The plotted serologic curves of each monkey are interesting in that two serologic tests, especially during the period of treatment, may or may not coincide during one simultaneous analysis of the serum (see text figures).

CONCLUSION

The serologic curves of the Philippine monkeys inoculated with yaws or both yaws and syphilis and treated with neosalvarsan at the stage of late serologic reactions can be compared favorably with those observed in man under the same conditions.

Of ten monkeys that were treated and had the infection for about the same length of time, those that had received previous treatment responded more promptly than those that had not received any. In the latter animals, however, there was only a gradual decrease in serologic reactivity with either the Wassermann or Kahn test during a period of two to six months of treatment.

ACKNOWLEDGMENT

I hereby express my sincere appreciation to my chief, Dr. Otto Schöbl, for his kind assistance.

[7] Philip. Journ. Sci. 35 (1928) 261; 40 (1929) 89–90.

ILLUSTRATIONS

TEXT FIGURES

THE EFFECT OF NEOSALVARSAN TREATMENT ON THE LATE SEROLOGIC POSITIVE VERNES, WASSERMANN, AND KAHN REACTIONS IN PHILIPPINE MONKEYS INOCULATED WITH YAWS OR BOTH YAWS AND SYPHILIS.

By CARLOS MONSERRAT

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TWO TEXT FIGURES

In a previous communication,(1) the results of the Vernes test performed with blood of Philippine monkeys inoculated with yaws, syphilis, or both, were demonstrated and compared with the results of the Wassermann and Kahn reactions.

The present study has the purpose to show the effect of neosalvarsan treatment on some animals that still show strong positive late serologic response with the three above-mentioned methods.

The changes in the degree of these three reactions, observed during the periods of treatment, were registered and compared by drawing serologic curves.

The majority of the monkeys used in the present experiment were repeatedly inoculated in the past at different intervals with both syphilis and yaws; the rest received inoculations only of living yaws and dead treponemas. One-half of the tested animals received also neosalvarsan injections, but later these monkeys were reinoculated with syphilis or yaws, and at present their blood shows positive reactions with the Vernes, Wassermann, and Kahn tests.

It has been demonstrated that monkeys, which become serologically negative after treatment, may become again positive after reinoculation with either killed or living yaws or syphilis treponemas.(2)

Marked serologic changes in the degree of the late Wassermann reaction have been noticed in human patients with chronic or latent syphilis under the influence of neosalvarsan treatment, especially with the employment of cholesterinized antigens.

These changes were manifested in the form of a strong positive Wassermann, becoming negative after a few injections of neosalvarsan and then becoming again positive with new neosalvarsan injections. This is particularly evident in cases of discontinued neosalvarsan treatment. Furthermore, the "reactivation" of the Wassermann test, as proposed by Millan, with the administration of small doses of neosalvarsan, is a well-known method employed in the serological diagnosis of cases of chronic or latent syphilis.

Syphilitic patients under the influence of neosalvarsan treatment and examined repeatedly with the Kahn test often do not show marked fluctuations in the degree of the serologic reactions compared with the Wassermann test. However, the Kahn reaction remains sometimes persistently positive in well-treated individuals in the absence also of clinical manifestations of syphilis.

Vernes, of the Prophylactic Institute of Paris, developed a new test for the serological diagnosis of syphilis. His method has been tried on a considerable number of syphilitic patients with very good results. The Vernes test is a quantitative flocculation test and has an advantage over the ordinary Wassermann and Kahn methods in that the readings are made more accurate with the photometer and the results are more stable or less fluctuating; therefore, the effect of the different drugs administered during the course of the disease can be easily evaluated by this method. It is important from the therapeutic standpoint to observe in the serologic curve of the patient the effect of each drug administered during the course of a particular treatment. In this respect the Vernes reaction is particularly useful.

MATERIAL INVESTIGATED

Through the courtesy of Dr. Otto Schöbl, formerly of the Bureau of Science, the sera of ten Philippine monkeys, inoculated with syphilis and yaws, were furnished me for the Vernes reaction.

The strain of *Treponema pallidum* employed in the inoculations was the well-known Nichols strain. The strains of *Treponema pertenue* were secured by direct inoculations from patients to the Philippine monkeys. The duration of the infection in the tested animals ranged from seven months to four years five months, and the history of each monkey is summarized in Table 1.

TABLE 1.—*Showing the number and kinds of injections, period of inoculation or infection, and previous treatment received by the experimental monkeys.*

PREVIOUSLY TREATED WITH NEOSALVARSAN.

Designation of monkey.	Inoculations.						Duration of infection up to the time of the present experiment.	
	Living syphilis.	Living yaws.	Yaws killed at 60° C.	First.	Last.	Total.	*Yrs.*	*mos.*
W-23	1	7	3	I-18-29	II-14-30	11	2	5
W-25	1	7	2	I-20-28	II-14-30	10	2	5
J-11	2	6	0	III- 9-26	I- 7-30	8	4	5
T-4	2	5	0	VII- 2-26	I- 7-30	7	4	2
K-28	0	2	0	XI -27-29	III-27-30	2	0	7

NOT PREVIOUSLY TREATED WITH NEOSALVARSAN.

Designation of monkey.	Living syphilis.	Living yaws.	Yaws killed at 60° C.	First.	Last.	Total.	Yrs.	mos.
J-18	0	2	1	IV-16-28	II-27-29	3	2	4
f-2	0	2	0	VI-25-28	II-27-29	2	2	1
U-1	1	4	3	VII-27-27	II-14-30	5	3	0
Z-1	0	1	(a)	(b)	VIII- 2-28	2	1	7
j-1	1	2	0	VIII-17-28	VI-22-29	3	1	9

[a] Tissue from yaws.

[b] Tissue from yaws; date unknown.

TABLE 1.—*Showing the number and kinds of injections, period of inoculation or infection, and previous treatment received by the experimental monkeys*—Continued.

PREVIOUSLY TREATED WITH NEOSALVARSAN.

Designation of monkey.	Neosalvarsan treatment previous to the present experiment.			Last serologic reactions before present experiment.			Serologic reactions at the time of the present experiment, December 9, 1930.		
	Last injection.	Total dose.	Duration of treatment.	Date.	Kahn.	Wassermann.	Vernes.	Kahn.	Wassermann.
			Mos.						
W-23	XII-14-28	0.19	6	VI-27-30	+++	++++	5	++	++++
W-25	XII-14-28	0.19	2	VI-27-30	++++	++++	6	++	++++
J-11	XII- 2-26	0.09	3	VIII- 6-30	++	++++	60	++++	++++
T-4	XII-14-27	0.115	3	X-25-30	+	++++	9	+++	++++
K-28	I-28-30	0.03	9	XI-27-29	++	++++	26	+++	++++

NOT PREVIOUSLY TREATED WITH NEOSALVARSAN.

Designation of monkey.	Last injection.	Total dose.	Duration of treatment.	Date.	Kahn.	Wassermann.	Vernes.	Kahn.	Wassermann.
J-18	0	0	0	X-25-30	++	++++	132	++++	++++
f-2	0	0	0	VIII- 6-30	++++	++++	42	++++	++++
U-1	0	0	0	VI-27-30	++++	++++	6	+++	++++
Z-1	0	0	0	V-25-30	+	++++	109	++++	++++
j-1	0	0	0	XII-17-30	++++	++++	57	++++	++++

For the present experiment the animals received several intramuscular injections of neosalvarsan, the injections being administered by Dr. Onofre Garcia, of the Bureau of Science. The doses and intervals of injections and the total amount of drug received by each monkey were recorded in the accompany-

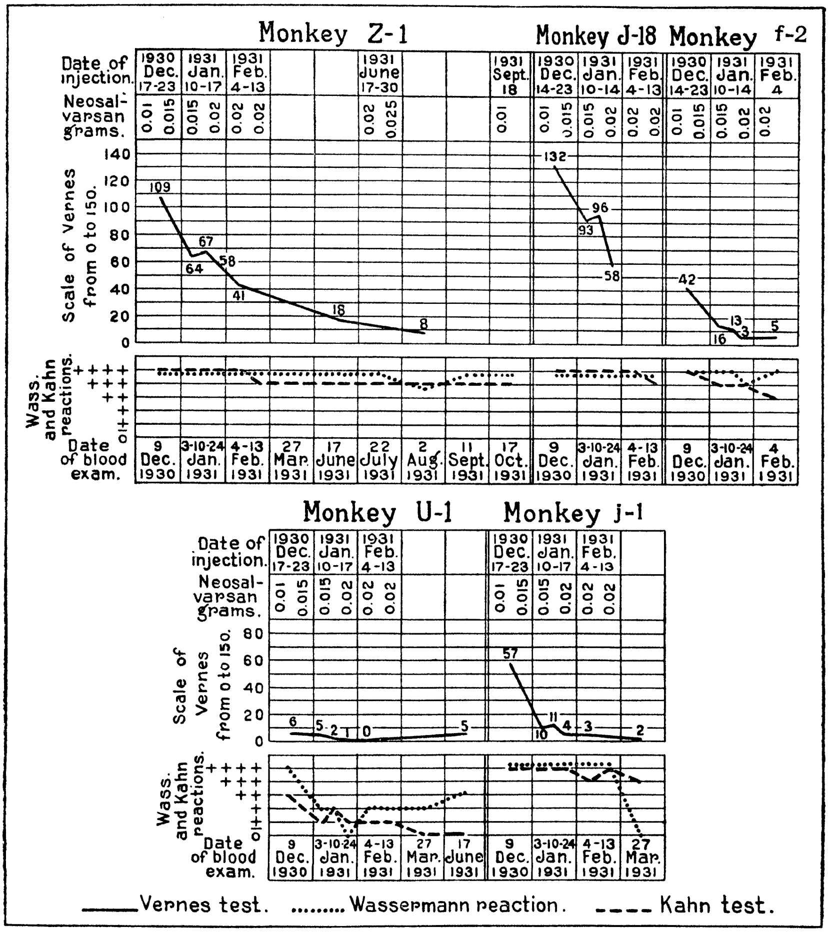

FIG. 1. Chart showing the effect of neosalvarsan treatment on the serologic curves of the Vernes, Wassermann, and Kahn reactions in five untreated monkeys inoculated with yaws and both yaws and syphilis.

ing charts (figs. 1 and 2). At the beginning of the experiment two treatments were given within two weeks and two successive serologic reactions were performed in the following two weeks. Later, due to signs of emaciation and toxicity in the animals, the bleeding and the treatment were made on the same day and with less regular intervals as the treatment advanced.

TECHNIC

The Wassermann and Kahn reactions were performed by Dr. Onofre Garcia, of the Bureau of Science. The Vernes test was performed by the writer.

The technic for the Vernes,(3) Wassermann,(4) and Kahn(5) tests was the same as in the previous experiments.

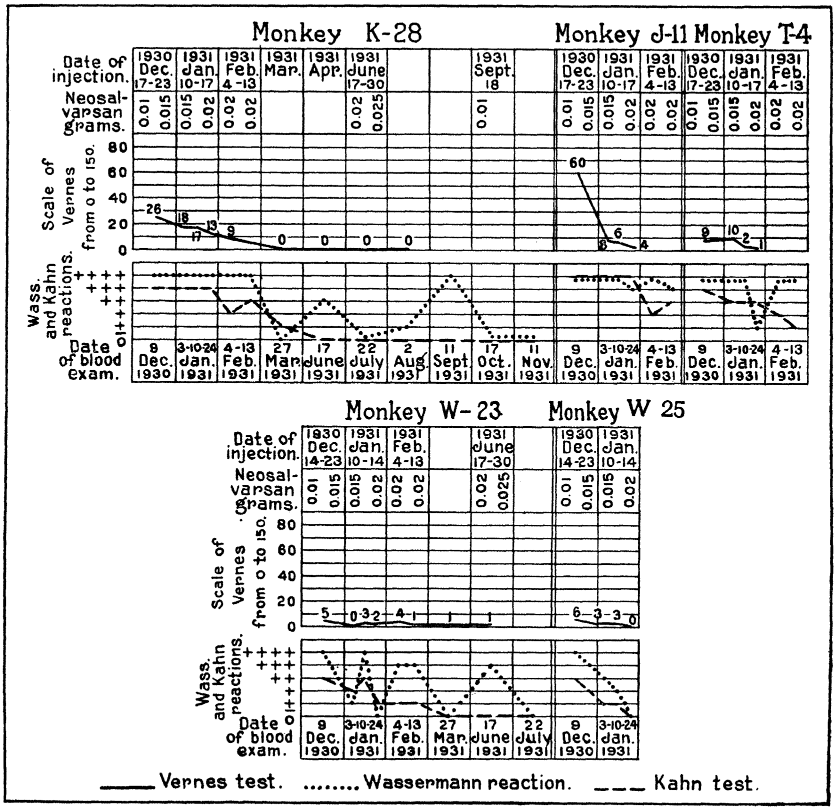

FIG. 2. Showing the effect of neosalvarsan injections on the serologic curves of the Vernes, Wassermann, and Kahn reactions in five monkeys inoculated with yaws and syphilis, which received previously, certain amount of the same drug.

In the Wassermann test the reading was made only from the tube containing the cholesterinized antigen. In the Kahn test the final results were an average of the reading of the three tubes.

DISCUSSION

The results recorded in Table 1 demonstrate that monkeys that did not receive neosalvarsan treatment in the past showed at the time of this investigation stronger positive Vernes, Wassermann,

and Kahn reactions than the previously treated monkeys. In the group of treated animals, it appears that the duration of the infection and the time that elapsed between the last dose of neosalvarsan and the last reinoculation have more influence on the degree of the Vernes and Kahn reactions than the number of reinoculations performed in the same animals.

This is illustrated in monkeys W–23, W–25, J–11, and T–4. Monkeys W–23 and W–25 received more reinoculations (11 and 10), but the duration of the infection was only two years five months. Monkeys J–11 and T–4, on the contrary, received fewer reinoculations (8 and 7), but the duration of the infection was four years five months and four years two months, respectively.

All these monkeys received approximately the same amount of neosalvarsan. Monkeys W–23 and W–25 received the last dose of the drug fourteen months previous to the last reinoculation, while monkeys J–11 and T–4 received their last dose of neosalvarsan two and three years, respectively, before the last reinoculation.

Monkeys W–23 and W–25 at the time of the present experiment showed weaker positive Vernes and Kahn reactions compared with monkeys J–11 and T–4.

The Wassermann reaction in all monkeys treated or untreated was found very strongly positive.

The effect of the present neosalvarsan treatment on the serologic curves of the Vernes, Wassermann, and Kahn reactions in the five untreated monkeys inoculated with yaws and both yaws and syphilis is given in the lower part of fig. 1.

In this figure the effect of each case of neosalvarsan can immediately be appreciated by the descent of the Vernes curve. The Kahn and Wassermann curves on the other hand remained unchanged during a period of three months in three of the infected monkeys (J–18, f–2, j–1) and in one monkey (Z–1) during a period of nine months.

The effect on the serologic Vernes, Wassermann, and Kahn reactions of the present neosalvarsan treatment in five inoculated monkeys, which received previously a certain amount of the same drug, is demonstrated in fig. 2.

This figure shows that the amount of reagins in the blood of each animal indicated by the serologic curve of the Vernes test decreases progressively after administration of each dose of neosalvarsan. On the other hand, the curve of the Wassermann reaction is very irregular; the results being sometimes negative,

sometimes very strongly positive in spite of the continuous administration of neosalvarsan.

This is particularly illustrated in monkeys K–28 and W–23. In these animals the Kahn test behaves almost the same as the Vernes reaction.

SUMMARY

The effects of neosalvarsan injections on the positive serologic Vernes, Wassermann, and Kahn reactions in ten Philippine monkeys inoculated with yaws and both yaws and syphilis are here presented and studied. The duration of the infection in the tested animals was from seven months to four years five months.

Five of these monkeys received, before the present experiment, certain amounts of neosalvarsan. These animals, however, were later reinoculated with syphilis or yaws. Five monkeys received no neosalvarsan injection whatsoever.

All the tested animals showed, at the time of this investigation, positive serologic Vernes, Wassermann, and Kahn reactions. Very strong positive serologic reactions, with all three methods, were particularly observed in the group of monkeys that did not receive previously neosalvarsan injections, with the exception of one monkey (U–1).

The duration of the infection, in the group of treated animals, has apparently more influence upon the degree of the Vernes and Kahn reactions than the number of reinoculations performed in these animals.

Marked serologic changes manifested in various degrees with the Vernes reaction were observed in all monkeys whether treated or untreated during the present course of neosalvarsan treatment. These serologic changes can be detected sooner with the Vernes test than with the Wassermann and Kahn tests. The Vernes reaction became more promptly negative or almost negative in the group of untreated animals.

The serologic curve of the Kahn test resembles the serologic curve of the Wassermann reaction in the group of untreated monkeys. These animals showed, under the influence of neosalvarsan treatment, very little change in the serologic curve of both the Kahn and Wassermann reactions, at least during the first three months following the administration of neosalvarsan.

The serologic curve of the Kahn test resembles the curve of the Vernes reaction only in the group of previously treated animals. It must be mentioned, however, that the Kahn reaction was found by Doctors Schöbl and Garcia to be less sentitive in monkeys than the Wassermann reaction. In human patients,

on the other hand, the Kahn test was found more persistently positive than the Wassermann test.

The serologic curved of the Wassermann reaction, particularly in the group of treated monkeys, was found very irregular and unstable. The Wassermann reaction was found sometimes very strongly positive, sometimes completely negative, during the present neosalvarsan treatment.

CONCLUSIONS

1. The Vernes test was found to be as sensitive a method as the Wassermann and Kahn reactions with the blood of Philippine monkeys inoculated with yaws or both yaws and syphilis.

2. Marked serologic changes, under the influence of neosalvarsan injections, can be more easily demonstrated and evaluated by the Vernes test than by the ordinary Wassermann and Kahn methods.

3. The Vernes reaction is a quantitative reaction and the results are more accurate than those of the ordinary Wassermann and Kahn methods, as the amount of reagin in the blood serum of infected animals can be estimated easily and more accurately by means of a photometer.

Neosalvarsan injections produce, in the blood of infected animals, certain changes in the amount of reagin. In the Vernes reaction these changes are estimated in the photometer and expressed by figures. The combination of figures will form later the serologic curve. The serologic curve in the Vernes reaction is more regular and less fluctuating than the Wassermann and Kahn serologic curves. The changes due to the neosalvarsan injections can be detected sooner and followed more closely in the Vernes reaction than those in the ordinary Wassermann and Kahn methods.

4. The Wassermann reaction apparently is not a good method to study the effect of neosalvarsan injections in the blood of infected monkeys on account of the various fluctuations of the Wassermann serologic curve, particularly in previously treated animals.

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ILLUSTRATIONS

TEXT FIGURES

The data on neosalvarsan treatment and the serological curves of Wassermann and Kahn tests were taken from Doctor Garcia's paper, "The effect of neosalvarsan treatment on the late serologic reactions of the Philippine monkeys inoculated with yaws or both yaws and syphilis," in this issue.

SCLEROTIUM STEM ROT OF DELPHINIUM AND OTHER ORNAMENTAL PLANTS IN TRINIDAD VALLEY, MOUNTAIN PROVINCE, PHILIPPINE ISLANDS.

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EIGHT PLATES

INTRODUCTION

The annual *Delphinium*, an ornamental plant, like other temperate zone ornamental plants, is grown successfully in Trinidad Valley and other places in the vicinity of Baguio, Mountain Province, Philippine Islands. In this *Delphinium* species and in many other ornamental plants grown in flower beds at the Trinidad Agricultural School, a certain stem and root-rot disease was found in May, 1932. The disease in the annual *Delphinium* species causes yellowing, wilting of the leaves, and finally drying up of the plants due to rotting of the roots and parts of the stem (Plates 1, 2, and 3). On the infected parts of these diseased plants a fungus with coarse white mycelia and numerous small round light brown to dark brown sclerotia, similar to *Sclerotium rolfsii* Sacc., was observed.

In the United States a crown and root rot of *Delphinium* species, *Funkia* spp., *Pentastemon barbatus* Roth, and *Valeriana officinalis* L. was first reported in Connecticut by Clinton(2) in 1907. In 1924, Welch(15) reported a sclerotial disease of cultivated delphinium in New York, Pennsylvania, Indiana, and New Jersey, and proved by inoculation that the organism is pathogenic to both the annual and perennial varieties of larkspur. Because he was unable to identify the fungus with any described species, he proposed the name *Sclerotium delphinii*. Gloyer and Glasgow(3) in 1924 also found the disease to be very abundant on a variety of delphinium from Philadelphia, and ascribed it to *Sclerotium delphinii* Welch. In 1927, Takahashi(12) reported a sclerotium disease of larkspur in Madison, Wisconsin, which in 1925 destroyed 25 per cent of the larkspur in one commercial nursery near Madison. This fungus in culture was similar to or identical with *Sclerotium delphinii* Welch.

Weber(14) in 1931 listed two species of delphinium as host plants to *Sclerotium rolfsii* in Florida. In Trinidad Valley, Mountain Province, Philippine Islands, the annual delphinium was found severely attacked by *Sclerotium rolfsii,* and as far as the writer is aware, the occurrence of *Sclerotium rolfsii* on delphinium in the Philippines has not been reported. It might be interesting, therefore, to report and describe the disease occurring in the annual delphinium and other ornamental plants in Trinidad Valley, the causal organism of which is different from the organism connected with crown and root rot of both the annual and the perennial delphinium in the United States.

GEOGRAPHIC DISTRIBUTION AND ECONOMIC IMPORTANCE

The fungus causing the stem and root-rot of delphinium grown in the Mountain Province, Philippine Islands, is of wide distribution. It has been found attacking various garden and ornamental plants in Trinidad Valley and in the lowland provinces of Luzon. This disease was previously found causing stem and root rot of beans and tomatoes in Trinidad Valley, and in 1932 it was found on delphinium, causing from 5 to 10 per cent infection in some beds, early in the season. Before the end of the season almost 25 to 30 per cent of the plants in the bed were infected and killed. Other ornamental plants, such as petunia, carnation, amarylli lily, and Watsonia, were also affected. In lowland provinces various garden and ornamental plants are found affected. In a flower garden in Manila about 80 per cent of the seedlings of a palm [*Adonidia merrillii* (Becc.) Becc.] were attacked, and a potted Amazon lily (*Eucharis grandiflora* Planch. and Linden) was completely destroyed by this fungus (Plate 8).

GENERAL SYMPTOMS

Delphinium plants infected with the stem and root-rot disease first show yellowing of the lower older leaves. Within a few days the upper leaves progressively turn yellow, with wilting of the terminal shoot, and finally the whole plant dries up and dies (Plates 1 and 2). When the plant is pulled out, a part, or the whole root system, or the stem is found to be either rotted or disintegrated, and on these infected regions there may be white tufts of mycelia or sclerotia (Plate 3). Infection may in certain cases appear on one side of the plant only, but as the fungus advances, the stem, crown, and roots are girdled or de-

cayed, and the infected plant usually topples over and can be pulled up easily, depending upon the stage of the disease. Further evidence of the disease is the appearance of the coarse radiating mycelia or small brown sclerotia of the fungus at or near the infected regions. Under favorable conditions the mycelia run up to the stem, or may be found ramifying on the ground near the infected plants. Numerous small brown sclerotia about the size of mustard seeds may be observed in these regions.

ISOLATION

A pure culture of the causal organism can be readily isolated from the infected plants either by placing in a moist chamber small portions of infected parts and allowing the fungus to develop its aërial fluffy mycelium, or by planting in poured agar plates small bits of infected tissues or mature sclerotia that have been surface-sterilized with 1: 1000 mercuric chloride. After two or three days subcultures from the edge of the colony can be made under sterile conditions. The fungus on potato-glucose agar produces a white, fluffy, mycelial growth, and within four to six days light brown to dark brown sclerotia almost the size of mustard seeds are produced (Plate 4).

PATHOGENICITY

The fungus is pathogenic on delphinium and many other plants. Successful infection was obtained when the mycelia or sclerotia were placed near the stem of the experimental plants. Infection was more rapid when the mycelia were inserted into a bruised stem or placed near an uninjured stem than when inoculations were made by placing the sclerotia near the stem. When the air was warm and moist, and the plants inoculated were young and succulent, delphinium plants died within a week, while more-succulent tomato or garden bean (*Phaseolus vulgaris* Linn.) seedlings died within two to five days. In these experiments the fungus was readily reisolated and is the same fungus as originally used.

IDENTITY OF THE FUNGUS WITH SCLEROTIUM ROLFSII

The fungus isolated from delphinium[1] and other flowering plants in Trinidad Valley, Baguio, Mountain Province, behaves in culture like the well-known *Sclerotium rolfsii* Sacc., as described by Higgins,(5) Taubenhaus,(13) Stevens,(11) and others.

[1] An identical fungus has been isolated from bean and tomato plants.

The fungus in culture produces a white and fluffy mycelium, and after four to six days sclerotia appear. The sclerotia produced in culture or those from the field are round, measuring usually from 0.5 to 1.6 mm, with most of the sclerotia falling between 0.8 and 1 mm. The sclerotia are at first white, become cream-colored, and finally turn light brown to dark brown. This fungus, compared in culture with the three authentic strains of *Sclerotium delphinii* from the United States, differed only in size and in the number of sclerotia. Gloyer and Glasgow(3) give dimensions of *S. delphinium* from pinhead size to as large as from 5 to 10 mm in length and about 2 to 3 mm in thickness. The sclerotia of the three *S. delphinii* strains cultured on potato-glucose agar are large and pitted, and vary from 1.2 to 4.5 mm long by 1.2 to 2.5 mm wide for Illinois strain I, 2.1 to 6.5 mm long by 1.6 to 3.5 mm wide for Illinois strain II, 2.5 to 5.0 mm long by 2.0 to 3.9 mm wide for Illinois strain III, and 1.8 to 8.5 mm long by 1.5 to 4.5 mm wide for Wisconsin 517 strain (Plates 5 and 6). The number of sclerotia produced by *Sclerotium rolfsii* varies from 100 to 400 or more, depending upon the media used, and in *S. delphinii* the number varies from 10 to 50, but in no case was it found to produce over 100 sclerotia in a single colony (Plate 7). From these findings it is evident that the organism causing crown and stem rot of delphinium in the Mountain Province, Philippine Islands, is *Sclerotium rolfsii* Sacc., and is, therefore, different from *S. delphinii* Welch, the organism causing crown and stem rot of delphinium in the United States. Furthermore, this fungus was compared with authentic cultures of *S. rolfsii* from the United States and was found to be identical with the latter.

CERTAIN FACTORS INFLUENCING THE DISEASE

The disease is more prevalent in light sandy soil than in heavy soil, and is favored by warm, moist weather. When the disease is established it spreads along the row in both directions, from one plant to another by migration of the fungus mycelium, or by transfer of the mycelia or sclerotia from one part of the field to another through cultivation. Air and moisture are necessary for infection. If the organism is buried deeply in the soil it becomes less active. The organisms can live saprophytically in the soil in its mycelial stage, and can resist unfavorable weather with its sclerotial bodies.

HOST RANGE OF SCLEROTIUM ROLFSII

This fungus, being one of the soil fungi attacking a wide variety of host plants, was reported serious on tomato by Halsted(4) in 1892 and by Rolfs(10) in 1893. Since that time various writers have reported it on various plants so that now it is known to be widespread in tropical and subtropical countries. Weber(14) in 1931 listed 189 host plants attacked by this fungus; *Delphinium ajacis* Linn. and *D. grandiflorum* Linn. are among the ornamental plants listed as infected in Florida. In the Philippines, Reinking(8, 9) reported a *Sclerotium* causing damping off of seedlings and stem rots in peanuts, coffee, rice, tobacco, garden bean, gabi [*Colocasia esculentum* (L.) Schott], soy bean, sweet potato, and yautia (*Xanthosoma sagitifolium* Schott). *Sclerotium rolfsii* was reported by Pereira(7) on Philippine rice, and in 1924 Ocfemia(6) found it causing fruit rot of tomato and pepper. In 1927, Atienza(1) found it on sitao (*Vigna sesquipedalis* Linn.), patola [*Luffa cylindrica* (L.) Roem.], Jerusalem artichokes (*Helianthus tuberosus* Linn.), "pongapong" [*Amorphophallus campanulatus* (Roxb.) Blume], *Caladium* spp., sugar cane, avocado (*Persea americana* Linn.), and squash (*Cucurbita maxima* Duch.). In a field survey made by the writer in 1930 and on various field trips made thereafter, the above-mentioned plants were found infected by *Sclerotium rolfsii,* and in addition, *Delphinium* species, carnation, amarylli lily, Watsonia, petunia, Amazon lily (*Eucharis grandiflora* Planch. and Linden) Plate 8, and "bunga de China" [*Adonidia merrillii* (Becc.) Becc.] were also affected by the same fungus. As the climate is favorable to fungus activity in the Philippine Islands, other ornamental and garden plants not heretofore reported might also be attacked by *S. rolfsii* in other localities.

SUGGESTION FOR CONTROL

The fungus *Sclerotium rolfsii* is readily transported from one locality to another in its mycelial or sclerotial stage, either with the soil, with the seedlings, or with seed boxes. Its spread in the field is accomplished by cultivation and excessive use of water. As this disease is rather difficult to control once it gets started, care must be taken to avoid its introduction to new localities. Infected plants and the soil around them should be removed and burned. Since the parasite becomes less active when it is buried deep in the soil, plowing deep or turning over

the surface soil to a depth of about 8 to 12 inches will greatly minimize the prevalence of the disease. For small infected flower beds or infected soil in pots, sterilization of the soil by firing or changing it with fresh uninfected soil is highly recommended. No chemical has yet been found to be effective in checking the advances of the pathogene once a plant has become infected.

SUMMARY

1. The crown and root-rot disease of delphinium due to *Sclerotium rolfsii* is reported for the first time on *Delphinium* sp. in Trinidad Valley, Mountain Province, Philippine Islands, causing a 5 to 10 per cent infection of delphinium plants in the flower beds at the Trinidad Agricultural School. Other ornamental plants were also infected, but the disease was more serious on the annual delphinium.

2. Infected plants first show yellowing of the lower leaves, but as the disease progresses, the upper leaves also turn yellow, the terminal shoots finally wilt, and within a few days the plants topple over, dry up, and die. The crown and roots of such plants either disintegrate or decay; the plants can be pulled up readily.

3. A pure culture of *S. rolfsii* was isolated and its pathogenicity was proven on delphinium and other garden plants, causing death within a week after inoculation.

4. The fungus in culture is identical with the authentic culture of *Sclerotium rolfsii* Sacc., from the United States, but differs from *S. delphinii* in the size, number, and markings of the sclerotia.

5. The disease is favored by warm and moist weather, and is more serious and prevalent in light, sandy soil than in heavy soil.

6. The fungus is known to attack 189 host plants. In the Philippines, in addition to various garden and field crops, it attacks *Delphinium* sp., carnation, amarylli lily, Watsonia, and petunia at Trinidad Agricultural School; and Amazon lily and "bunga de China" [*Adonidia merrillii* (Becc.) Becc.] in flower gardens in Manila.

7. No control measure has been worked out, but recommendations are made to prevent and minimize the occurrence of the disease.

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ILLUSTRATIONS

Plate 1

Delphinium in a flower bed infected with *Sclerotium rolfsii* Sacc. Note the yellowing, wilting, and dying condition of the plants. The fungus mycelia and sclerotia are very evident on the infected stem.

Plate 2

Delphinium plants infected with *Sclerotium rolfsii.* The plants in the foreground are dead or dying, while those in the background are still healthy. Later these plants also were infected and died.

Plate 3

Delphinium plants infected and killed by *Sclerotium rolfsii* Sacc. Note the complete rotting of the tissues of the crown and roots. The white tufts of mycelia and the young sclerotia of the causal fungus are quite evident on the infected regions.

Plate 4

Pure culture of *Sclerotium rolfsii* isolated from infected delphinium plants. Note the characteristic light to dark brown sclerotia about the size of mustard seeds.

Plate 5

Sclerotium rolfsii isolated from delphinium compared with three strains of *Sclerotium delphinii* from the United States. Fig. 1, *Sclerotium rolfsii.* Figs. 2, 3, 4, strains of *Sclerotium delphinii* from Illinois. Fig. 5, *Sclerotium delphinii* from Wisconsin. Note the difference in the number and size of sclerotia between *S. rolfsii* and *S. delphinii; S. rolfsii* sclerotia are smaller and numerous, those of *S. delphinii* are larger and fewer, and are "pitted."

Plate 6

Photograph showing the relative sizes of sclerotia produced by *Sclerotium rolfsii* and *Sclerotium delphinii.* Fig. 1, *Sclerotium rolfsii.* Fig. 2, *Sclerotium delphinii* Wisc., strain 517. Figs. 3, 4, and 5, *Sclerotium delphinii,* Illinois strains I, II, and III.

PLATE 7

Sclerotium rolfsii and *Sclerotium delphinii*, "Wisconsin 517" on potato glucose agar showing the marked differences between the two organisms (7-day-old colony).

PLATE 8

A potted Amazon lily (*Eucharis grandiflora* Planch. and Linden) infected with *Sclerotium rolfsii*. Note the course white mycelia and the sclerotia of the fungus. This plant was from a flower garden in Manila.

PLATE 1.

PLATE 2.

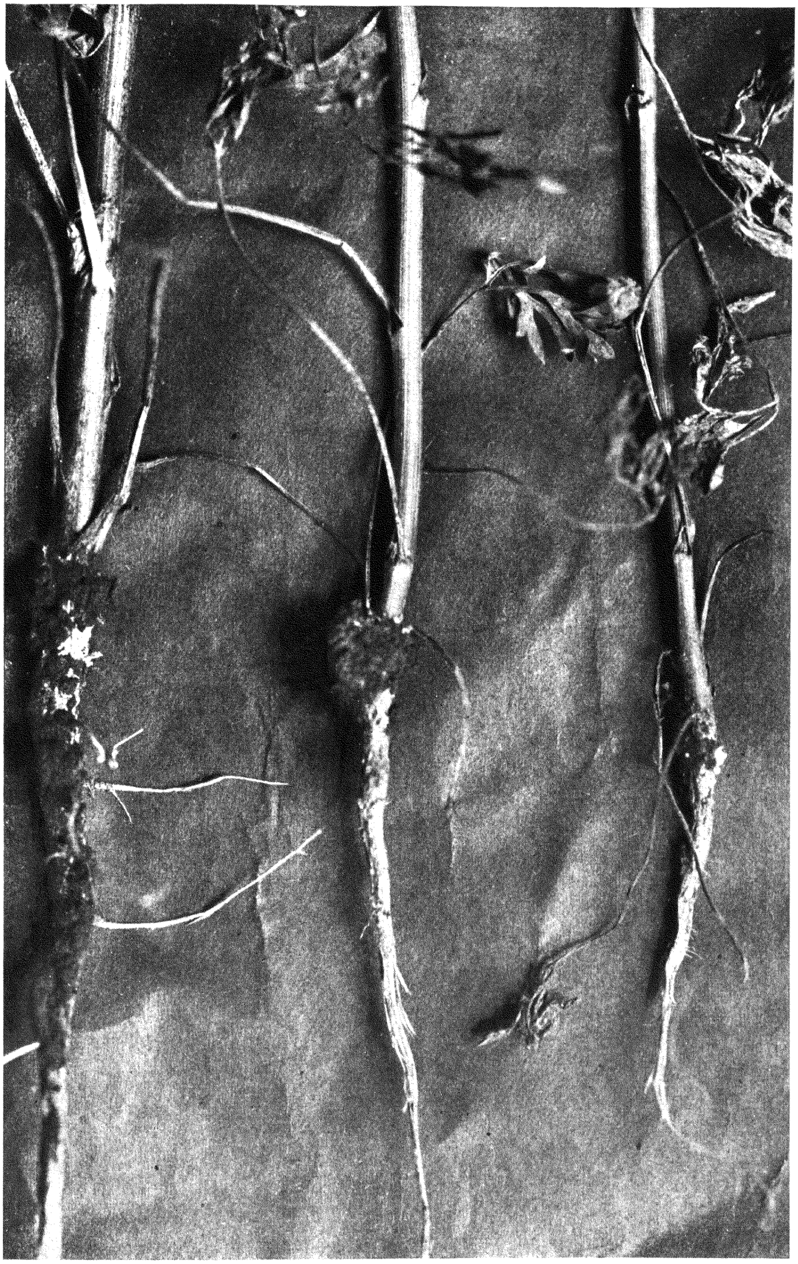

PLATE 3.

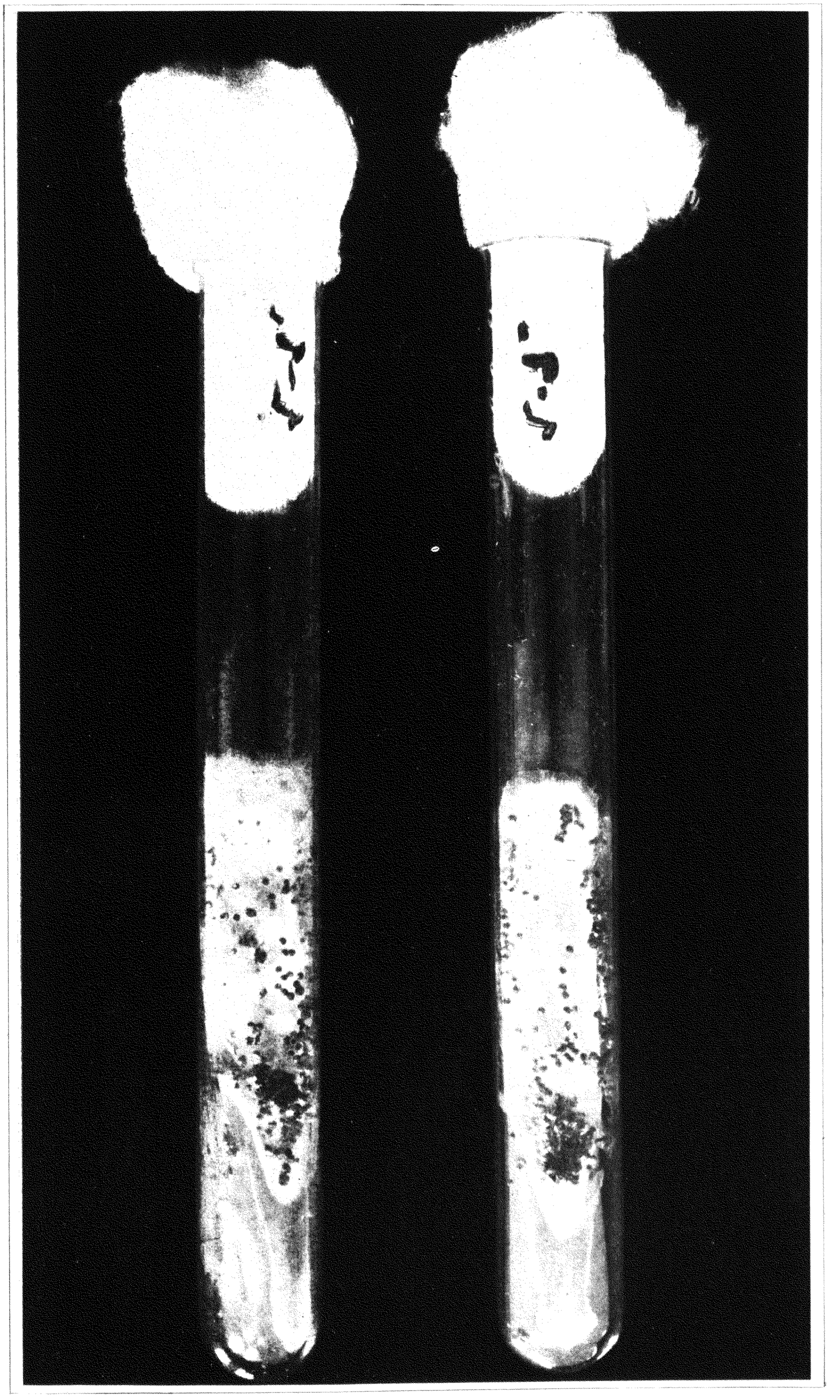

PLATE 4.

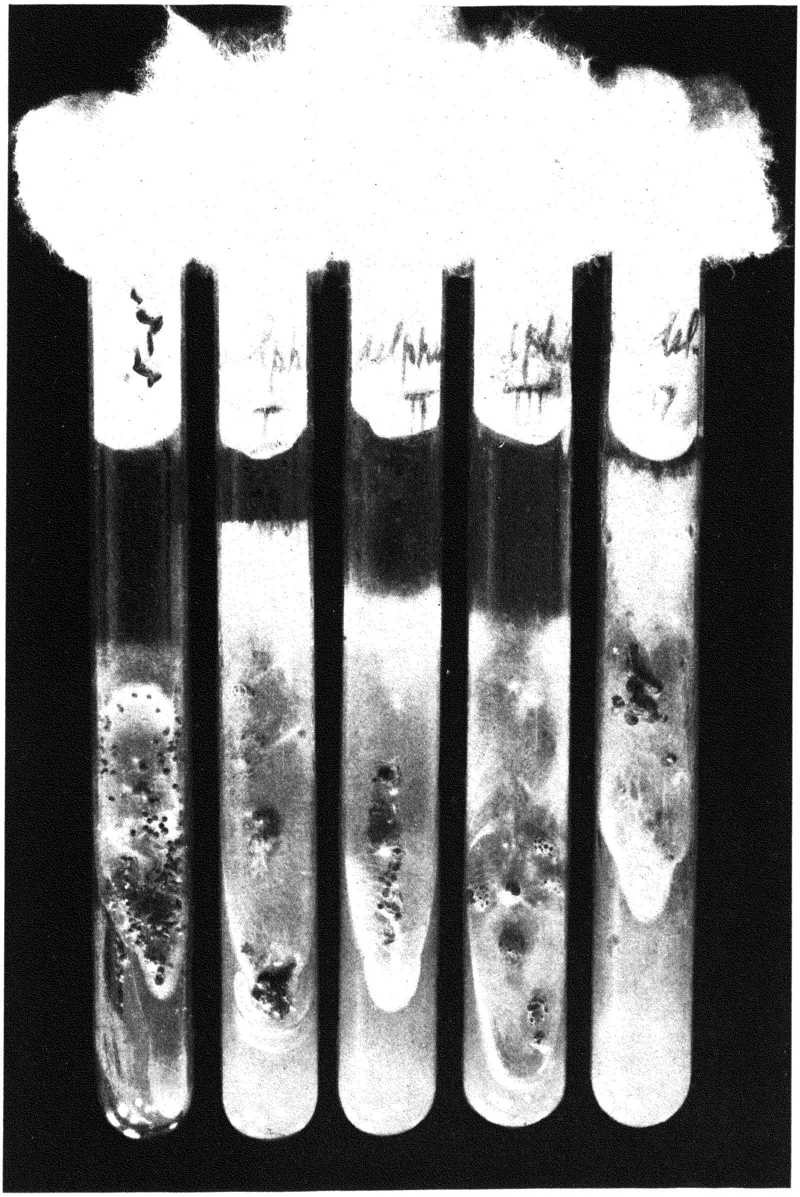

PLATE 5.

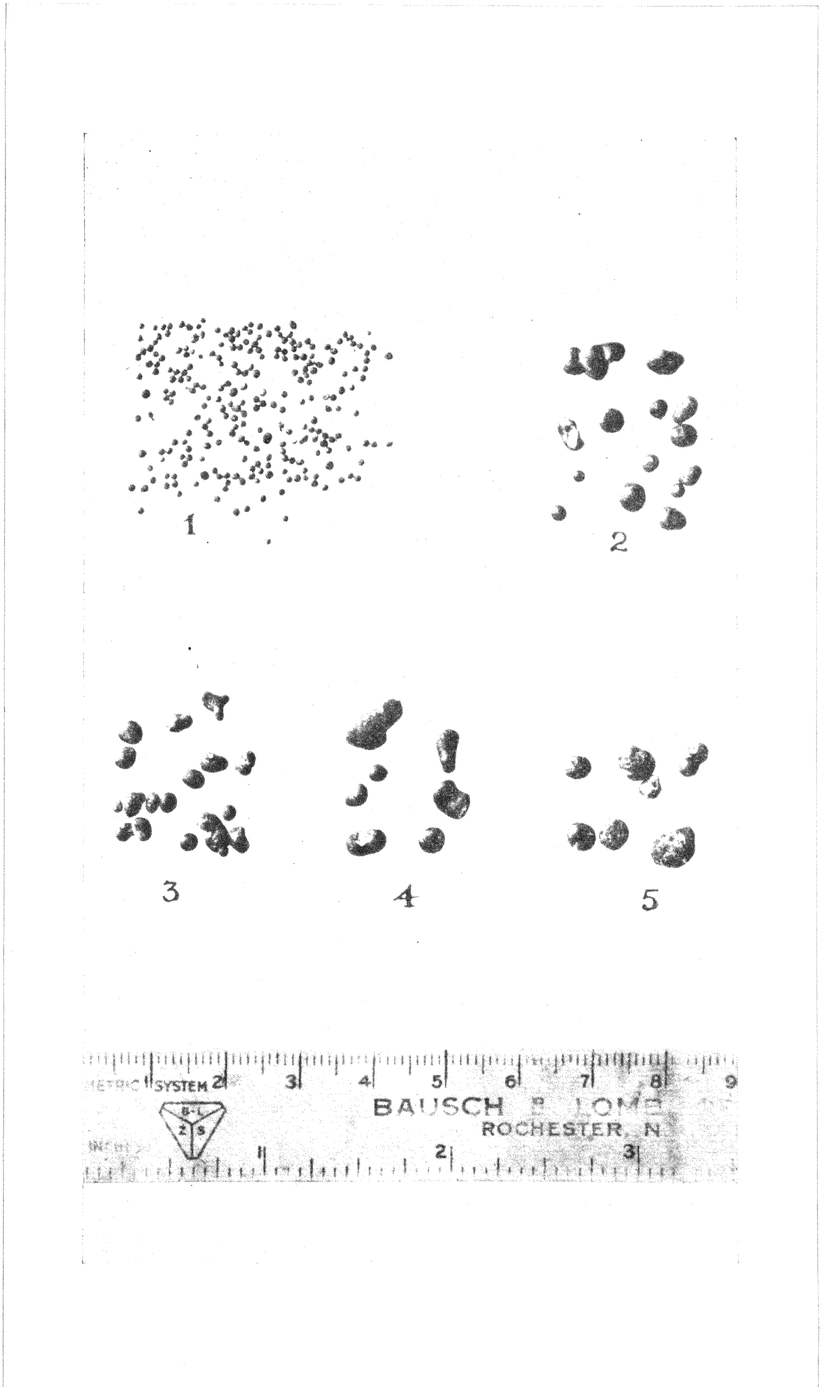

PLATE 6.

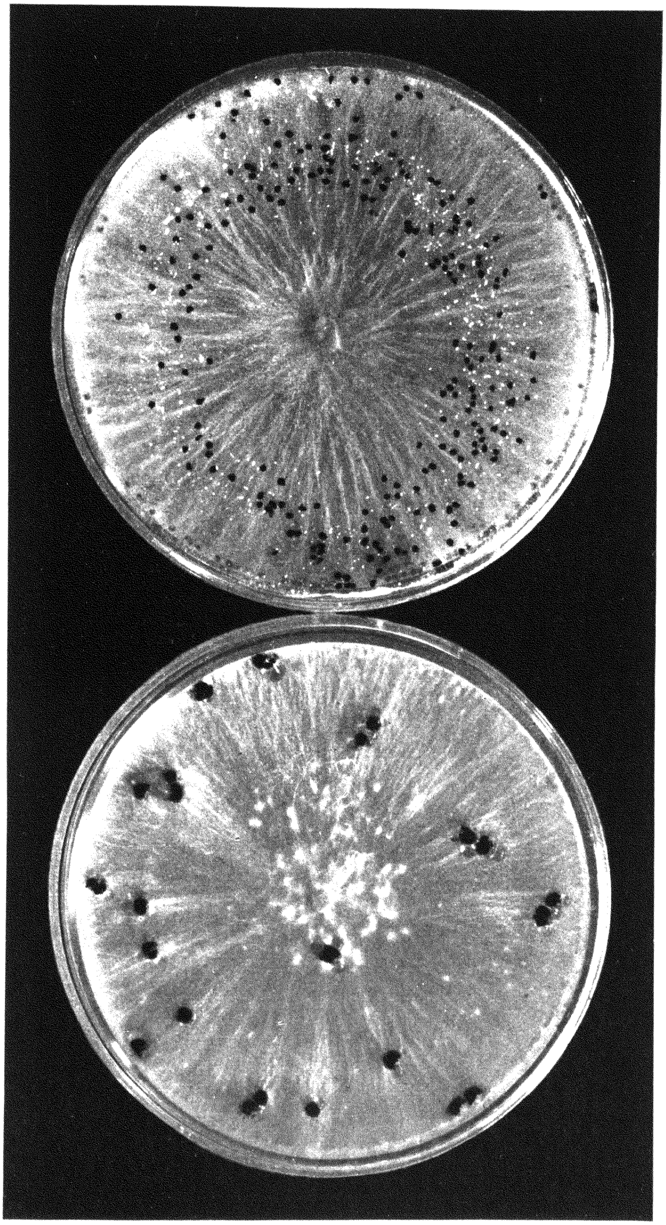

PLATE 7.

PLATE 8.

THE ROOT-KNOT NEMATODE, HETERODERA RADICICOLA (GREEF) MULLER, OF TOMATO AND OTHER PLANTS IN THE PHILIPPINE ISLANDS.

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EIGHT PLATES

INTRODUCTION

The disease, generally known as root knot, caused by *Heterodera radicicola* (Greef) Muller,[2] has been known to be a serious pest of crop plants. In some countries the pest is so prevalent that susceptible crops have to be abandoned and thousands of dollars spent for steam and chemicals in attempts to control the disease. In the United States, especially in the sandy truck and cotton regions of the Southern States, the root knot is a serious outdoors disease. Thus, in Florida, Godfrey (9) reported that in one county the loss on snap beans, cabbage, celery, eggplant, potatoes, lettuce, peas, and tomatoes amounted to 150,000 dollars. Gilbert (8) also reported that the loss due to the nematode for the entire cotton belt in 1917 was estimated at approximately

[1] Read before the First Philippine Science Convention, Manila, March 16, 1932. An abstract was published in the proceedings of the society with the permission of the Director of the Bureau of Science.

[2] Cobb (5) in 1924 proposed the name *Caconema radicicola* (Greef) Muller for this species. However, Goodey (12), discussing the nomenclature of the root-knot nematode, states that, according to the law of priority of the international rules of zoölogical nomenclature, the nematode named by Greef as *Anguillula radicicola* (= *H. radicicola* of Muller) should have the generic name *Anguillulina* and, therefore, should be called *Anguillulina radicicola* Greef. Because of the confusion that might arise in literature and for the purpose of this article the well-known binomial of the pest, *Heterodera radicicola* (Greef) Muller, is retained.

200,000 bales of cotton and 100,000 tons of seed worth 16,000,000 dollars.

In the Philippines the root-knot nematode is common and widespread, attacking abacá, sugar cane, tobacco, tomato, beans, cowpeas, "sitao," garden beets, celery, pepper, sweet potato, and some weed plants. Because the climate of the Philippines is favorable to the continued activity of the parasite, and since all important truck and field crops are now affected, it is feared that the disease may become more widespread and serious and limit the cultivation of the important garden and field-crop plants, as it has in other countries. The results of our studies of the disease, especially as it affects the tomato, one of the major commercial truck and field crops in the Philippines, are here presented.

GEOGRAPHIC DISTRIBUTION AND ECONOMIC IMPORTANCE

Berkeley(1) first reported the disease in Europe in 1855. Since then various workers have studied and reported the disease as attacking various agricultural plants, and now it is known to have a world-wide distribution and to attack over five hundred species of plants. In the Philippines, the disease was reported by Reinking(17) on tobacco and sugar cane in 1916, by David and Roldan(6) on tobacco in 1926, and by Ocfemia and Calinisan(16) on abacá in 1928. Dr. M. M. Alicante, formerly soil chemist of the Bureau of Science, informed the writers that during his soil survey in Cagayan Valley in 1926, he found the root-knot nematode common and its infestation serious on some old tobacco farms along the river banks.

In a plant-disease survey made by the senior writer during the summer of 1930, and in various field trips in 1931 and 1932 through the northern and central provinces of Luzon, the root-knot nematode was found more serious in light sandy soil than in any other kind of soil, affecting various crop and weed plants. In Binalonan, Pangasinan Province, 100 per cent of the garden beets grown in the old school garden were infected and badly attacked, so that the roots were badly deformed and unmarketable. At the Central Luzon Agricultural School, Muñoz, Nueva Ecija Province, a plot of cowpeas and "sitao" showed 100 per cent infection and the plants yielded only a few pods. The disease was also found on the "American" celery in the Chinese gardens in Manila, in the seedbeds in Trinidad Valley and Camp 7, Baguio, Mountain Province, and on tomato, sweet potato, and *Phaseolus lathyroides*, from our new pathological plots in Ma-

nila and in Alabang, Rizal Province. On tobacco and tomato the disease was found in Ilocos Norte, La Union, Pangasinan, Bulacan, Nueva Ecija, Rizal, Laguna, and Batangas Provinces, causing considerable damage. In Cagayan Valley, especially in the light sandy soils, the disease is so important on tobacco that from 50 to 100 per cent infection is not uncommon in most tobacco fields. No data on the aggregate loss due to the disease can be presented, but where it is bad and widespread it is a limiting factor in crop production. The extent of distribution is not completely known, but as the climate of the Philippines is ideal for the pest, it might be found in other islands and provinces not heretofore reported.

SYMPTOMS

The symptoms of root knot on tomato, tobacco, cowpea, or other plants suffering from the disease are quite identical. In general, the infected plants are dwarfed or stunted and wilt or "flag" during the hot dry part of the day, but recover towards evening when the temperature becomes lower. The most characteristic symptom of the disease is the production of galls or abnormal swellings on the root system (Plates 1, 2, 3, and 4). These galls may assume various shapes and sizes, or may coalesce together giving the root system a knotty, swollen, or thickened appearance. The presence of these galls on the roots interferes with the normal physiological functions of the roots, which results in wilting even when the soil is moist. Because of this pathological condition of the root the plant in time ceases to grow and may die prematurely. Plants at any stage of growth are susceptible to infection. Young plants infected early and severely show yellowing of the first few leaves, cease growing, and finally die before they develop many leaves (Plate 6, fig. 3, and Plate 8). Older plants infected during their premature or mature stage may continue to grow, with little or no effect on the growth, and the production of fruit may be reduced but slightly. These plants may be recognized in the field by their pale to yellowish green leaves; upon pulling, galls are found in the root system. If some of these galled roots are split open, the eggs or larvæ of the causal nematode are found.

CAUSAL ORGANISM

The root-knot nematode found on tomato, tobacco, and other plants in the Philippines is the well-known *Heterodera radicicola* (Greef) Muller.

Eggs.—The eggs are almost elliptical or ovoid. Bessey(2) gave measurements for the eggs as 85 to 95 μ long by 34 to 40 μ wide, with an absolute average of 92 by 38.4 μ. Byars(3) states that the eggs are 88 by 34 μ, while Godfrey(9) found the eggs to be about 100 μ. Ocfemia and Calinisan(16) found that the egg of the nematode from abacá is from 76 to 108 μ long by 36 to 48 μ wide, and the average 91.8 by 41.3 μ. Measurements of one hundred eggs from the galls of the infected roots of tomato showed that they vary from 81.7 to 95.0 μ in length and 34.2 to 43.7 μ in diameter, with an average of 90.3 μ long and 39.4 μ wide.

The larvæ.—The larvæ are small slender worms, blunt at the anterior and tapering at the posterior end to a pointed tail. Bessey(2) found them to be 375 to 500 μ in length and about 12 to 15 μ in greatest thickness. Byars(3) found them to be 400 μ in length, while Godfrey(9) found them to be $\frac{1}{80}$ to $\frac{1}{50}$ of an inch, or about 312.5 to 500 μ long, and the diameter about $\frac{1}{30}$ of its length, or about 10.4 to 16.6 μ. Ocfemia and Calinisan(16) found that the nematode larva from abacá measures 331.6 to 464.2 by 16.2 to 25.9 μ, and the average size is 409.5 by 18.8 μ. Our measurements of eighty young larvæ from galled tomato roots showed that they are from 310 to 465 μ long and 12.5 to 17.1 μ thick, or an average of 387.5 μ long and 15.2 μ thick.

Mature female.—The mature female is usually flask- or pear-shaped, and glistening pearly white; it can be seen embedded in the galled tissues of the root. Bessey(2) states that it is 400 to 1,300 μ in length and 270 to 500 or even 700 μ in the greatest diameter, and the average measurements about 800 μ in length and 500 μ in diameter. Byars's(3) measurement for the mature female is about 0.5 millimeter, or 500 μ, while Godfrey(9) states that it is from $\frac{1}{40}$ to $\frac{1}{25}$ of an inch, or about 625 to 1,000 μ. Ocfemia and Calinisan(16) found the mature female nematode on abacá to be from 720 to 1,280 μ in length and 400 to 800 μ in diameter. The writers found that in one hundred mature females the range was from 775 to 1,271 μ in length and 418 to 667.07 μ at the greatest diameter, or an average of 917 by 527 μ.

Mature male.—The mature males are long, slender, and worm-like and can be distinguished from the larvæ by their size and striated cuticle. They are not easy to find, and out of several attempts we were able to measure only three males. They were from 992 to 1,550 μ long and 38.7 to 40 μ thick. Bessey(2)

states that they are usually from 1,200 to 1,500 μ long and 30 to 36 μ thick. Byars(3) reports that the mature male is a little more than 1 millimeter long, while Godfrey(9) found it to be from $\frac{1}{20}$ to $\frac{1}{16}$ of an inch long, or about 1,250 to 1,562.5 μ, and not over one-fortieth as thick as long, or about 31.25 to 39 μ in thickness.

From the above measurements it is evident that the size of the eggs, larvæ, mature female, and mature male of the nematode causing root knot on tomato plants, as here reported, lies near or within the measurements for *H. radicicola* studied by Bessey,(2) Byars,(3) Godfrey,(9) and Ocfemia and Calinisan.(16) Therefore, it is not unsafe to assume that the nematode in question is the well-known root-knot nematode *H. radicicola* (Greef) Muller. In these studies no attempt has been made to examine the internal structure of the pest, but specimens were shown to Dr. M. Tubangui, parasitologist of the Bureau of Science, who confirmed our determination. Plate 5 shows the stages in the life cycle of the root-knot nematode.

PATHOGENICITY TEST

Tomatoes or other susceptible plants when grown in nematode-infected soil are readily infected and show characteristic nematode galls on the roots. In a set of experiments, larvæ in water suspension were poured near the stems of tomato, tobacco, and cowpea plants growing in 8-inch pots. When after twenty-five days these plants were lifted, galls were already produced on the roots, while the check plants, in soil to which the nematode was not added, showed no galls on their root systems. Microscopic examination of the galled roots showed the presence of the root-knot nematode, *H. radicicola*. In another trial tomato seeds were planted in soil mixed with galled roots, and after thirty-five days when the seedlings were pulled up abundant galls were found on the root system.

ARE THERE HETERODERA RADICICOLA STRAINS?

In the Philippines the nematodes causing root knot on tomato, tobacco, table beet, cowpea, celery, and a legume weed, *Phaseolus lathyroides* Linn., are morphologically alike and perhaps of the same physiological strain. In cross-inoculation experiments the nematode from tomato, tobacco, and cowpea can easily infect tomato, tobacco, cowpea, beet, celery, and *Phaseolus lathyroides,* while the nematode on garden beet, celery, and

P. lathyroides can likewise readily infect tomato, tobacco, cowpea, beet, celery, and *P. lathyroides*. The galls produced as a result of infection varied only slightly in size and form. In these experiments galled roots were mixed thoroughly with the sterile soil in which seedlings or seeds were planted.

Further experiments were conducted in which samples of nematode-infected soils from Los Baños, Laguna Province, Binalonan, Pangasinan Province, and from the pathological plot of the Bureau of Science, Manila, were planted with five tomato varieties. When the plants were examined thirty-five days after planting all the plants gave 100 per cent infection. The galls produced in the roots were identical. The results of the above experiments indicate that there is probably but one common species of *H. radicicola* attacking these crops in the Philippines. This conclusion is in agreement with that of Bessey,(2) who found that the root-knot nematodes were mutually interchangeable on the plants he experimented with, and that the root-knot nematode is not markedly differentiated into strains peculiar to certain hosts.

TABLE 1.—*Cross-inoculation experiments using nematode-infected soil from three localities.*

Tomato varieties tested.	Sources of nematode-infeted soil.					
	Pathological plot, Bureau of Science.		Los Baños, Laguna Province.		Binalonan, Pangasinan Province.	
	Plants inoculated.	Plants infected.	Plants inoculated.	Plants infected.	Plants inoculated.	Plants infected.
American varieties:						
Perfection	5	5	11	11	5	5
Matchless	5	5	4	4	5	5
Native varieties:						
Balayan	5	5	5	5	5	5
Laguna	5	5	5	5	5	5
Wild cherry (Lemery)	5	5	11	11	5	5

INFECTION EXPERIMENTS

Amount of moisture and nematode infection.—Godfrey(10) found that moisture plays a small part in the development of root knot so long as the moisture content of the soil is favorable to the growth of the crops. He obtained root-knot infection in infested soil with a water-holding capacity ranging from 20 to 100 per cent, but serious infection was observed

where the soil moisture was best for plant growth. Within the range of 40 to 80 per cent of the water-holding capacity of the soil root knot was abundant, but there was very little difference in the root-knot development. Below 40 per cent, which is too dry for good growth of ordinary plants, and above 80 per cent, which is more or less muddy, considerable root knot is still found. Jones (13) likewise found that infection with nematode was obtained in soil with a moisture ranging from 10 to 100 per cent.

The results of experiments conducted in the greenhouse also showed that root-knot infection can be obtained even when the soil is saturated with water or kept quite dry but still wet enough to maintain plant growth. Eight pots containing infested soil were placed in a shallow galvanized-iron can filled with water. The soil was therefore very wet. After one, two, three, four, and five days tomato seedlings were planted. At the end of thirty-five days from the date of planting all showed nematode-gall infection.

In the other experiment, pots with infected soil were planted with tomato seedlings, and allowed to grow in the greenhouse with only a small amount of water added once every few days to keep the plants from dying. Again, when the plants were examined forty days later, all gave 100 per cent infection.

The effect of flooding on nematode infection.—Jones (13) found that twenty-eight days of continuous flooding were not sufficient to destroy the nematode in gall-infested soils. In a series of experiments nematode infection was obtained even after infected soil had been flooded for thirty-five days. In these experiments, uniformly infected soil was put in 1-cubic-foot cement crocks, flooded with sterile water until the soil was submerged 2 inches, and the water allowed to stand for 1, 5, 10, 20, 25, 30, and 35 days in the greenhouse. At the end of each flooding interval, the water was drawn off by a drainage hole at the bottom. After twenty-four hours of draining, with the soil still wet, a layer of sterile soil was added on the surface where the tomato seeds were planted. After planting, and even during the course of observation, no water was added as the soil was still moist. As checks of the above experiments, crocks of the same size and capacity were filled with the same infected soil sample, kept moist, and planted with tomato seeds at the beginning and at the end of the experiment. Thirty-five days from the date of planting the plants were lifted carefully and the roots examined.

As shown in Table 2, nematode infection was obtained even after infested soil had been flooded for thirty-five days. The percentage of infection, however, decreased to 39 per cent with an average of 0.6 gall per plant, while the checks which were planted at the beginning and at the end of the experiment showed 100 and 96 per cent infection with 7.9 and 3.2 galls per plant, respectively. Flooding at shorter intervals showed abundant gall formation, but a gradual decrease in the percentage of infection was noted.

In another set of experiments, infected soil was put in a large galvanized can and then submerged in water for 25, 30, 35, and 40 days. After each time interval, a portion of the flooded soil was put in 8-inch pots. These pots were allowed to drain for forty-eight hours before tomato seeds were planted. At the end of thirty-five days the plants were examined, and again a high rate of infection was obtained after flooding the soil for twenty-five days, but at the end of thirty-five and forty days the infection was greatly reduced.

The results of the above experiment show that a majority of the nematodes on badly infested soil can be killed by flooding, and that after thirty-five and forty days of flooding infection is greatly reduced. No attempt has been made to determine how long infected soil can be freed by flooding, but it seems that longer flooding periods would completely eliminate nematodes in the soil. Observation in the Philippines seems to substantiate this opinion, as in the case of rice fields kept under water for two to four months, which are usually free from the root-knot nematode.

TABLE 2.—*Effect of flooding infected soil on the root-knot nematode.*

Treatment of soil.	Plants examined.	Infection.	Average number of galls.
		Per cent.	
Not flooded [a]	102	100.0	7.9
Flooded 1 day	130	85.4	4.1
Flooded 5 days	48	83.3	2.6
Flooded 10 days	66	86.3	4.2
Flooded 15 days	47	83.0	2.7
Flooded 20 days	106	75.5	1.4
Flooded 25 days	68	64.0	1.3
Flooded 30 days	62	77.0	3.8
Flooded 35 days	66	39.0	0.6
Not flooded [a]	76	96.0	3.2

[a] Check. The soil for check crocks was taken from the same soil sample and was kept moist, but not flooded.

The effect of desiccation on root-knot infection.—The results of a series of experiments show that nematodes can be killed by desiccation in the soil. The length of time required to kill all the nematodes, however, seems to depend upon the moisture content of the soil. Jones(13) found that galls put in air-dry soil for one and one-half to two weeks failed to produce infection when susceptible plants were planted.

In two series of experiments uniformly infected sandy-loam soil of known percentage of moisture, was mixed thoroughly with infected roots, put in 8-inch pots, and allowed to dry in the greenhouse for various lengths of time up to thirty-five days. At the end of each drying period, the percentage of moisture still remaining in the soil was determined, and then tomato seeds were planted. After the seeds had been planted, the soil was always kept moist to keep the plants in good growth. The plants were examined after thirty-five days from the date of planting. Table 3 is a summary of the results obtained.

TABLE 3.—*Effect of desiccating nematode-infected soil in the greenhouse and root-knot infection on tomato seedlings.*

Series and sample.	Duration of air drying.	Moisture in the soil sample.[a]	Plants examined.	Root-knot infection.
	Days.			*Per cent.*
Series I:				
0	Check.	[b] 11.0	----------	----------
1	2	6.6	25	100
2	5	4.5	30	100
3	10	2.8	25	100
4	15	2.2	20	100
5	20	2.1	30	100
6	25	2.0	30	16.7
7	30	2.0	25	0
8	35	2.0	25	0
Series II:				
0	Check.	[b] 15.1	75	100
1	10	8.1	75	100
2	15	6.9	75	100
3	20	6.1	50	100
4	25	5.6	75	100
5	30	4.9	70	100
6	35	2.6	135	2.2

[a] The per cent of moisture present in the sample of soil after drying in the greenhouse for a given number of days.

[b] Moisture present in the soil sample before drying in the greenhouse.

In series 1, only 16.7 per cent infection was obtained at the end of twenty-five days, and no infection was found after thirty or thirty-five days of drying. In series II, it will be noted that

100 per cent infection was obtained in soils after drying for thirty days, but after thirty-five days the infection decreased to 2.2 per cent. The difference in the length of time required to free the soil from nematodes in this case is apparently due to the difference in the percentage of moisture in the soil when the experiments were started. While our results differed from those of Jones,(13) it is believed that this discrepancy is due to the initial soil moisture when the experiments were started. In our experiments nematodes were either eliminated, or a large percentage of them were killed within twenty-five and thirty-five days of drying. In one case no infection was obtained after drying potted infected soil for thirty days in the greenhouse.

BIOLOGY OF THE LARVÆ

Sensitiveness of larvæ to complete dryness.—Larvæ are very sensitive and are readily killed by desiccation. In a series of experiments one drop of larvæ in water suspension was placed on glass slides and allowed to dry in the laboratory at room temperature for 1, 3, 4, 5, 6, 7, 8, 10, and 15 minutes. In these experiments, time was recorded when the slide was free from visible water and then further examined under a microscope for free water. After each time exposure, the slides were moistened with a drop of distilled water and kept moist in a Petri dish for forty-eight hours, after which they were examined for dead larvæ. As shown in Table 4, the larvæ were not killed after they had been exposed to dryness for three and four minutes at room temperature. After 5, 6, 7, and 8 minutes of drying, however, 10.1, 47.0, 70.0, and 90.7 per cent, respectively, were found dead. After 10, 15, and 20 minutes, however, all the larvæ were dead and remained dead even when allowed seventy-two hours in moist condition to recover. These dead larvæ showed no motion and were either straight or slightly curved. The check slides, in which the larvæ were kept moist all the time in a Petri dish, were all alive at the end of ninety-six hours, after which they were discarded. In another series of experiments, young larvæ just out of the egg sacs were exposed to the same treatment. Desiccation at room temperature for two minutes did not kill them all, but they were killed in three minutes, confirming the results of Godfrey and Hoshino.(11)

The results, therefore, show that the time required to kill the larvæ depends upon the stage of maturity, the very young larvæ being more sensitive than older ones.

TABLE 4.—*Sensitiveness of root-knot nematode larvæ to desiccation at room temperature (28–32° C.).*

Exposure.	Larvæ under observation.	Recovery of larvæ after they were placed in moist condition for 48 hours.	Larvæ killed in the treatment.
Mins.		*Per cent.*	*Per cent.*
1	8	100.0	0.0
3	5	100.0	0.0
4	5	100.0	0.0
5	18	89.9	10.1
6	17	53.0	47.0
7	13	30.0	70.0
8	15	9.3	90.7
9	20	0	100.0
10	25	0	100.0
15	25	0	100.0
20	20	0	100.0

Longevity of larvæ in water.—Larvæ are more tolerant to moist conditions without food than to desiccation. Larvæ in water suspension were placed on glass slides and kept moist in the laboratory at room temperature, and only a few survived at the end of thirty days in this condition without food. At the end of 18, 24, 30, and 35 days, 73.9, 92.2, and 100 per cent dead larvæ were found from one slide, while on another slide 42.6, 84.4, and 100 per cent larvæ were dead at the end of 18, 24, and 30 days.

In another series of experiments, a drop of larvæ in water suspension was placed in each of four concave glass slides and kept in the laboratory for 3, 8, 14, 25, and 30 days in a moist condition. In order to keep the slides moist, they were put in moist Petri dishes and a drop of water was added into each dish from time to time. At the end of twenty-five days the first three slides had 100 per cent dead larvæ, while slide IV had 90.1 per cent. At the end of thirty days this slide showed 100 per cent dead larvæ. The results show that the larvæ, which

are sensitive to drying, can live for twenty-five to thirty days in a moist condition without food in the laboratory (Table 5). It was observed that larvæ of the younger stage or larvæ that are newly hatched died very much sooner than larvæ of the older stages.

TABLE 5.—*Longevity of larvæ in water.*

Slide No.	Larvæ used.	Dead larvæ after—				
		3 days.	8 days.	14 days.	25 days.	30 days.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
I	26	46.2	61.5	92.3	100	100
II	20	55.0	75.0	85.0	100	100
III	40	57.5	67.5	85.0	100	100
IV	70	24.3	32.9	62.8	90.1	100

Overwintering the root-knot nematode.—Perhaps, as in other tropical countries, the root-knot nematode remains active and can produce infection on susceptible plants throughout the year in the Philippine Islands. In a series of experiments in the greenhouse, susceptible crops were readily infected at any time of the year when planted in infected soil exposed to outside conditions throughout the year. Furthermore, field observations on dry farms have shown that nematode-infected plants are found at any season of the year. This is in agreement with Bessey's findings(2) that in southern Florida where the weather is warm the root-knot nematode does not have a dormant period and is active all the year round on galled roots of annual or perennial plants. In northern Florida, however, the activity of the nematodes is lessened during the winter months when the weather is colder. In the northern States their activity almost ceases, and perhaps all are killed where winters are severe. In this connection Bessey(2) further states that the nematodes are inactive when the soil temperature falls below 50° F. Godfrey,(10) in a critical study, found that below 16° C. the root knot is substantially decreased, at 10 to 12° C. infection is very rare, and at higher temperatures root knot is abundant at any temperature that the host will tolerate. As the climate is always warm in the Philippines, there is no reason to doubt that the pest can remain active and infect susceptible plants all the year round, thus making it possible for the nematode pest to be a serious problem in the Philippines once it is well established in a locality.

RELATIVE SUSCEPTIBILITY OR RESISTANCE OF TOMATO VARIETIES TO ROOT-KNOT NEMATODE

Malloch(14) in his studies on *H. radicicola* found several tomato varieties and hybrids susceptible to root knot. In our studies the American and Philippine tomatoes, which were tested in the greenhouse, were found all susceptible to this disease. In these experiments, tomato seeds were planted in 12-inch pots containing nematode-infested soil. After thirty-five days from the date of planting, the plants were lifted carefully, the roots were washed, and the percentage of infection, the average number of galls, and the average height per plant determined. Table 6 is a summary of the results obtained.

It will be seen that all the varieties are susceptible and showed a high percentage of infection. As indicated by the percentage of infection, average number of galls on the root system, and average height of plants in the variety, the relative degree of susceptibility greatly varies. Yellow Plum, Chalk's Early Jewel, June Pink, Red Cherry, Red Pear, Penn. State Earliana, Sunnybrook Earliana, The Burpee, Burpee Fordhook First, Burpee Self Pruning, and Marglobe, of the American tomatoes; and the Lemery Wild Cherry tomato, Native Pasig Nos. 1 and 5, Native San Isidro No. 1, Native Tarlac Nos. 2 and 3, Calumpit No. 2, Native Mariquina, and Native San Carlos No. 2, of the Philippine tomatoes, showed a greater degree of resistance than any of the other varieties tested. These tomatoes were but slightly affected in growth although the percentage of infection was high or, as in some cases, the galls on the roots were numerous. Plates 6 and 7 show some of the varieties that exhibit some degree of resistance and those that are susceptible. The tomato varieties, such as the Yellow Plum, Red Cherry, and other small-fruited wild types, showed only small galls, or in some instances only brownish lesions were found on the root system. No swellings were noted on the stem. The other varieties listed in the table are classed as either susceptible or very susceptible. These varieties, before the end of thirty-five days, showed many dead seedlings due to root-knot nematode infection. These varieties produced numerous galls and swellings on the stem (Plate 8). Remarks on the relative susceptibility of these tomato varieties are noted in Table 6. As far as observed, there is no variety that showed true resistance or immunity, but in general the wild small-fruited tomato showed a greater degree of resistance than the more-fleshy fruited American or Philippine tomatoes.

TABLE 6.—*Relative susceptibility of American and Philippine tomatoes to root-knot nematode, H. radicicola (Greef) Muller.*[a]

[+, Resistant; ++, moderately susceptible; +++, susceptible; ++++, very susceptible.]

Variety.	Source of seed sample.	Number of plants examined.	Infection.	Average number of galls per plant.	Average height per plant.	Suscepti-bility.
AMERICAN TOMATOES.			*Per cent.*		*cm.*	
Beef Steak	Burpee Seed Co	57	100	14.4	14.4	+++
Bonny Best	do	35	100	20.7	10.6	+++
Burpees Dwarf Giant	do	23	100	9.4	4.7	++++
Burpees Fordhook First	do	60	100	7.2	12.2	++
Burpees Self Pruning	do	37	100	8.3	14.9	++
Break o' Day	do	90	100	16.9	10.3	+++
Chalks Early Jewel	do	71	91.5	3.3	20.5	+
Columbia Wilt Proof	Job Wyatt & Co	50	100	11.7	10.6	+++
Columbia Wilt Proof, Maule's	Maule's Seed Co	43	100	13.8	10.7	+++
Dwarf Stone	Burpee Seed Co	56	100	20.8	4.6	++++
Early Detroit	do	28	100	12.2	5.6	++++
Golden Dwarf Champion	do	50	100	8.7	6.8	++++
Gulf State Market	do	26	100	20.2	10.2	++++
June Pink	do	63	100	12.0	20.0	+
Kilgores Special	Kilgore Seed Co	36	100	14.6	10.5	+++
Sunny Brook Earliana	Burpee Seed Co	36	100	6.0	13.1	++
Livingstone Globe	do	43	100	11.3	11.5	+++
Marglobe	United States Department of Agriculture	74	100	11.8	13.5	++
Do	Burpee Seed Co	53	100	7.5	13.0	++
Marvel	United States Department of Agriculture	42	100	16.5	5.3	++++
Norton Wilt Resistant	Steckler Seed Co	57	100	12.8	10.2	+++
Penn. State Earliana	Burpee Seed Co	63	100	14.7	16.9	+
Ponderosa, True Giant	do	42	100	12.6	12.0	+++
Red Cherry	do	57	100	4.0	20.0	+
Red Pear	do	50	48	4.3	17.0	+

Sparks Earliana	Burpee Seed Co.	46	100	14.0	11.6	+++
The Burpee	do	72	100	5.8	13.0	++
Truckers Favorite	do	100	100	14.4	11.7	++++
Whole Salad	do	67	100	17.2	13.2	+++
Yellow Plum	do	45	84.4	4.1	22.0	+
PHILIPPINE TOMATOES						
Native Bureau of Plant Industry	Bureau of Plant Industry, P. I.	21	100	13.6	9.5	+++
Native Calumpit No. 2	Calumpit, Bulacan	84	100	9.7	8.6	++
Native Calumpit No. 4	do	52	100	12.0	([b])	+++
Native Mariquina	Mariquina, Rizal	22	100	11.0	10.2	++
Native Mariquina No. 1	do	32	100	16.4	9.4	++++
Native Muñoz	Muñoz, Nueva Ecija	72	100	15	([b])	+++
Native Pasig No. 1	Pasig, Rizal	97	100	7	([b])	+
Native Pasig No. 3	do	33	100	9.0	8.1	+++
Native Pasig No. 5	do	37	100	12.5	12.8	++
Native Pasig seedling	do	82	100	16.0	([b])	+++
Native San Carlos	San Carlos, Pangasinan	125	100	8.0	([b])	++
Native Santa Cruz	Santa Cruz, Laguna	72	100	16.0	7.0	++++
Native Santa Cruz No. 1	do	87	100	24.0	([b])	++++
Native San Isidro	San Isidro, Nueva Ecija	29	100	16.6	7.1	++++
Native San Isidro No. 1	do	18	100	16.0	10.8	+
Native San Isidro No. 2	do	23	100	16.0	10.3	++
Native Tarlac No. 1	Tarlac, Tarlac	80	100	26.0	([b])	++++
Native Tarlac No. 2	do	15	100	4.8	6.6	++
Native Tarlac No. 3	do	12	100	21.5	10.5	++
Native wild cherry (Lemery)	Lemery, Batangas	80	100	42.0	13.2	+

[a] Remarks on susceptibility are based on general stand of seedlings before pulling out from pots.

[b] The data on average height were lost.

TABLE 7.—*Relative susceptibility of tomato varieties obtained from different sources.*

[+, Resistant; ++, moderately susceptible; +++, susceptible; ++++, very susceptible.]

Variety.	Source of seed sample.	Plants examined.	Infection.	Average galls per plant.	Average height per plant.	Suscepti-bility.
			Per cent.		cm.	
Break o'Day	Russell Heckle Seed Co	100	100	14.0	13.1	++
Do	Burpee Seed Co	146	100	14.1	10.7	+++
Break o'Day New	Job P. Wyatt & Sons	59	100	16.9	8.1	+++
Do	United States Department of Agriculture	33	100	12.8	6.1	++
Columbia Wilt Proof, Maulis	Wm. H. Maule Seed Co	43	100	13.8	10.7	+++
Do	Job P. Wyatt Seed Co.	50	100	11.7	10.6	+++
Do	United States Department of Agriculture	25	100	8.0	7.0	+
Gulf State Market	Burpee Seed Co	26	100	20.2	10.2	++++
Do	H. G. Hastings Co	31	100	10.6	7.7	+++
Do	Wm. H. Maule Seed Co	20	100	14.0	7.4	+++
Livingstone Globe	Peter Henderson & Co	17	100	12.2	13.9	++
Do	Burpee Seed Co	43	100	11.3	11.5	+++
Do	Wm. H. Maule Seed Co	31	100	14.1	8.7	+++
Do	Ferry Morse Seed Co	18	100	7.2	7.4	+
Marglobe	United States Department of Agriculture	74	100	11.8	13.5	++
Do	Burpee Seed Co	53	100	7.5	13.0	++
Marglobe Wilt Resistant	T. W. Woods & Sons Co	69	100	12.0	10.2	++
Do	Great Northern Seed Co	50	100	15.2	10.5	+++
Do	Arthur G. Lee Seed Co	71	100	16.4	9.3	+++
Do	Ferry Morse Seed Co	32	100	14.0	9.5	+++
Do	Job P. Wyatt Seed Co.	30	100	20.7	8.8	++++
Marglobe, Starks New	Starks Bros. Seed Co	36	100	14.0	8.7	+++
Marglobe, Kilgores Bred-rite	The Kilgores Seed Co	33	100	14.1	8.8	+++
Marglobe, Wilt Resistant	Wm. H. Maule Seed Co	48	100	17.3	8.5	+++
Do	H. G. Hastings Co	38	100	12.8	8.2	+++

Marglobe	Peter Henderson & Co	33	100	15.0	8.0	+++
Do	Russell Heckle Seed Co	30	100	14.4	7.0	+++
Marglobe, New	Van Anthwerp Seed Co	26	100	10.3	6.8	+++
Marglobe	Livingstone Seed Co	41	100	16.8	8.5	++++
Marvel (Hansings)	do	42	100	17.8	7.8	++++
Do	United States Department of Agriculture	42	100	16.5	5.3	++++
Norduke Wilt Resistant	T. W. Woods Seed Co	79	100	17.5	9.4	++++
Do	H. G. Hastings	44	100	20.7	8.8	++++
Do	Job P. Wyatt & Son	39	100	7.6	7.9	++
Do	United States Department of Agriculture	42	100	16.3	7.7	++++
Norton Wilt Resistant	Steckler Seed Co	57	100	12.8	10.2	+++
Do	Job P. Wyatt & Sons	41	100	14.0	10.1	++
Do	Great Northern Seed Co	26	100	19.7	8.9	++++
Do	United States Department of Agriculture	32	100	15.3	8.2	++++
Do	Russell Heckle	13	100	19.0	8.0	++++
Do	Burpee Seed Co	48	100	11.8	7.9	+++
Do	T. W. Woods	65	100	12.0	7.7	+++
Do	Wm. H. Maule & Sons Co	36	100	18.3	6.7	++++
Do	Ferry Morse Seed Co	80	100	15.9	6.2	++++
Do	H. G. Hastings Seed Co	43	100	13.5	7.3	+++
Norton Improved (Starks Blight-resister)	Starks Bros. Seed Co	40	100	16.0	8.3	+++

SUSCEPTIBILITY OR RESISTANCE OF A GIVEN TOMATO VARIETY OBTAINED FROM DIFFERENT SOURCES

In a series of trials we found no appreciable difference in the relative susceptibility or resistance to nematode infection of a given tomato variety obtained from different sources. In these experiments, few of the important American market tomatoes were tested in the same manner as in the above-mentioned experiments. The results are summarized in Table 7. Some difference in the relative susceptibility is found, however, in the different varieties, but only slight, if any, difference is noted when seeds of the same variety are obtained from different sources.

HOSTS RANGE ON HETERODERA RADICICOLA IN THE PHILIPPINES

The root-knot nematode is now known to attack over 500 species of plants. However, some plants affected vary in their degree of susceptibility. In a limited field survey and in artificial inoculation experiments in the greenhouse nearly all the common economic and weed plants in the Philippines were successfully inoculated or found naturally infected in the field with the root-knot nematode.[2] Among the economic plants affected are—

Ampalaya, *Momordica charantia* L.
Cucumber, *Cucumis sativus* L.
Melon, *Cucumis melo* L.
Patola, *Luffa acutangula* (L.) Roxb.
Upo, *Lagenaria leucantha* (Duch.) Rusby.
Watermelon, *Citrullus vulgaris* Schrad.
Tomato, *Lycopersicum esculentum* Mill.
Tobacco, *Nicotiana tabacum* L.
Eggplant, *Solanum melongena* L.
Cabbage, *Brassica oleracea* L. var. *capitata* L.
Mustard, *Brassica integrifolia* (West) O. E. Schulze.
Radish, *Raphanus sativus* L.
Sitao, *Vigna sesquipedalis* Fruw.
Sincamas, *Pachyrrhizus erosus* (L.) Urban.
Seguidilla, *Psophocarpus tetragonolobus* (L.) DC.
Beet, *Beta vulgaris* L.
Papaya, *Carica papaya* L.
Abacá, *Musa textilis* Neé.
Rice, *Oryza sativa* L.

[2] The writers are indebted to Dr. E. Quisumbing, botanist, Bureau of Science, for the identification of some of the plants.

Corn, *Zea mays* L.
Sugar cane, *Saccharum officinarum* L.
Onion, *Allium cepa* L.
Garlic, *Allium sativum* L.

Among the weed plants affected are *Ageratum conyzoides* L., *Amaranthus paniculatus* L., *Corchorus* spp., *Phaseolus lathyroides* L., *Kyllinga monocephala* Rottb., *Peperomia pellucida* (L.) HBK., *Portulaca oleracea* L., *Scoparia dulcis* L., and *Lindernia viscosa* (Willd.) Merr. Rice, corn, garlic, onion, peanuts, sincamas, and seguidilla are resistant to the root-knot nematode. Most of the weeds mentioned above are either susceptible or very susceptible to the pest. Table 8 shows the results obtained, together with an indication of the relative susceptibility of each host.

TABLE 8.—*Economic and weed plants artificially or naturally found infected with the root-knot nematode, H. radicicola (Greef) Muller, in the Philippines.*[a]

Host.		Plants examined.	Infection.	Remark on susceptibility.[d]
Common name.	Scientific name.			
ECONOMIC PLANTS			*Per cent.*	
Abacá	*Musa textilis* Neé			++
Ampalaya [b]	*Momordica charantia* L.	10	100	++++
Bean	*Phaseolus vulgaris* L.			
Canadian Wonder		5	100	++
Kentucky Wonder		3	100	++
Beet	*Beta vulgaris* L.	10	100	++++
Cabbage	*Brassica oleracea* L. var. *capitata* L.	32	100	+++
Camote [b]	*Ipomoea batatas* L.			++
Celery, "American"	*Apium graveolens* L. var. *dulce* DC.	15	100	+++
Corn	*Zea mays* L.			
Yellow Flint		22	63.6	+
White Corn		20	100	+
Lagkitan [b]		20	100	+
Cowpea	*Vigna sinensis* (L.) Savi			
New Era		20	100	++
Paayap [b]		17	100	+++
Paayap pinungo [b]		26	100	+++
Cucumber	*Cucumis sativus* L.	20	100	++++
Eggplant	*Solanum melongena* L.	25	100	++
Garlic	*Allium sativum* L.	15	100	+
Melon	*Cucumis melo* L.	10	100	++++

[a] The writers are indebted to Dr. E. Quisumbing, botanist, Bureau of Science, for the identification of the plants listed.
[b] Native common names in the Philippines.
[d] +, resistant; ++, moderately susceptible; +++, susceptible; ++++, very susceptible.

TABLE 8.—*Economic and weed plants artificially or naturally found infected with the root-knot nematode, H. radicicola (Greef) Muller, in the Philippines* [a]—Continued.

Host.		Plants examined.	Infection.	Remark on susceptibility.[d]
Common name.	Scientific name.			
ECOMOMIC PLANTS—ctd.			*Per cent.*	
Mungo [b]	*Phaseolus radiatus* L.	10	100	++
Mustard	*Brassica integrifolia* (West) O. E. Schulz	25	100	+++
Okra	*Abelmoschus esculentus* (L.) Moench	5	100	++++
Onion	*Allium cepa* L.	10	50	+
Papaya	*Carica papaya* L	22	100	++
Patola [b]	*Luffa acutangula* Roxb	4	100	+++
Peanut	*Arachis hypogaea* L.	15	100	+
Upo [b]	*Lagenaria leuchantha* (Duch.) Rusby	10	100	++++
Radish	*Raphanus sativus* L.	25	100	+++
Rice	*Oryza sativa* L.			
Dumali [b] (upland variety)		40	25	+
Seguidilla [b]	*Psophocarpus tetragonolobus* (L.) DC	7	87.7	+
Sincamas [b]	*Pachyrrhizus erosus* (L.) Urban	20	50	+
Pangasinan seeds		9	77.8	+
Bulacan seeds		10	70.0	+
Bureau of Plant Industry seeds		15	66.7	+
La Union seeds		11	100	+
Sitao [b]	*Vigna sesquipedalis* Fruw.	5	100	++++
Squash	*Cucurbita maxima* Duchesne	25	100	++++
Sugar cane	*Saccharum officinarum* L.			+
Tomato [c]	*Lycopersicum esculentum* Mill.	75		++++
Tobacco	*Nicotiana tabacum* L			
Batec [b]		25	100	++++
Bansoroy [b]		30	100	++++
Viscayan [b]		25	100	++++
Watermelon	*Citrullus vulgaris* Schrad.	15	100	++++
WEED PLANTS				
Damong-pallas [b]	*Ageratum conyzoides* L.	5	100	+
Kalunai [b]	*Amaranthus paniculatus* L.	15	100	++++
Saluyot [b]	*Corchorus* sp.	25	100	+
	Phaseolus lathyroides L.	10	100	++++
Mutha [b]	*Kyllinga monocephala* Rottb.	5	100	+
Olasiman ihalas [b]	*Peperomia pellucida* (L.) HBK	5	100	+++
Ulasiman [b]	*Portulaca oleracea* L.	10	100	++
Sampalokan [b]	*Scoparia dulcis* L.	5	100	++
	Lindernia viscosa (Willd.) Merr.	5	100	++
"Tagulinai" [b]	*Vernonia cinerea* (L.) Less.	6	100	++

[a] The writers are indebted to Dr. E. Quisumbing, botanist, Bureau of Science for the identification of the plants listed.

[b] Native common names in the Philippines.

[c] For tomato varieties refer to Table 7.

[d] +, resistant; ++, moderately susceptible; +++, susceptible; ++++, very susceptible.

DISCUSSION AND SUGGESTION FOR CONTROL

In the present investigation, experiments on control measures applicable to Philippine conditions have not been undertaken. As the disease attacks the underground parts of the plant, any protective material applied on the roots will be useless. The control of nematodes must, therefore, be directed against the eradication of the pest from the soil, and this can only be accomplished by sterilizing the soil with steam or chemicals, or by rotation of crops to starve out the organism. Another method is the selection and development of resistant strains.

The control of the root knot has been well studied in the United States and effective control measures have been recommended. Because of the high cost of materials, these measures are of a limited practical application, so much so that even the truck farmers in the United States cannot well afford the expenses entailed in the purchase of the chemicals and machinery used. Under Philippine farming conditions, while there are measures which cannot be recommended, other workable control and preventive measures can be tried. We will mention and discuss some of these well-known control measures.

Soil sterilization by steam.—Sterilization by steam is the most practical method of control in soils in greenhouse and seed beds or in small plots. It is accomplished by passing steam through perforated pipes at a depth of one foot below the surface for one or two hours, depending upon the steam pressure and type of soil.(9) Another way of using steam is the "inverted pan method," in which an iron or a wooden pan of convenient size is used. The pan is inverted over the bed, the edges thrust into the soil, and steam under pressure forced into the pan through a special inlet for from one-half to two hours.(9) Small quantities of soil or soil in pots or flats can be readily sterilized in an autoclave for two to five hours or in specially constructed vaults heated to 110° C. or more for two or more hours, the length of time depending upon the steam pressure. Pouring hot water directly on pots, flats, and benches at the rate of 7 gallons per cubic foot is also satisfactory,(4) and although its application is limited, it is effective in ridding the soil of nematodes where steam is not available.

Soil sterilization by chemicals.—The use of chemicals has been tried by various workers, but in almost all cases the chemicals found to be effective are too expensive for practical use in the field. Durez(7) in 1917 recommended 200 pounds of

sodium cyanamide (NaCn) per acre dissolved in water and applied at the rate of $\frac{1}{3}$ gallon per square foot of soil, followed by a second treatment a week later; this gave perfect control in the greenhouse. Watson[19] in 1921 likewise recommended the use of dry powdered calcium cyanamide at the rate of 600 to 800 pounds per acre carried down to a depth of about 18 inches by irrigation water. After this treatment, ammonium sulphate at the rate of 900 to 1,200 pounds to the acre is applied. Because of the high cost of these chemicals for field operations, their use is not popular with farmers in the United States. These chemicals have been adopted for seed beds and small truck patches where intensive cultivation of a susceptible crop is practiced. McClintock[15] and Stone and Smith[18] tried other chemicals such as carbon bisulphide, corrosive sublimate, calcium carbide, ammonium sulphate, formaline, nicotine, benzene, kerosene, magnesium sulphate, common salt, potassium nitrate, magnesium sulphate, calcium sulphate, kainit, sodium nitrate, and lime, but no satisfactory results were obtained.

Rotation of crops.—Rotation of crops for two or three years is generally recommended as an effective means of control.[8, 9, 20] The crops known to be resistant or immune to root-knot nematode in the United States are the true grasses (crabgrass and Bermuda grass), most varieties of corn, wheat, rye, and some varieties of oats, velvet beans, and beggar weed, and the iron and Bradham cowpeas. Peanuts, onions, parships, strawberries, and turnips are slightly affected. These crops have been recommended as rotation crops before planting the choice susceptible crops. Our studies have shown that rice, corn, onion, garlic, peanuts, sincamas, and seguidillas are also highly resistant to the root-knot nematode, and these should be recommended as rotation crops in the Philippines if the resistant foreign plants cannot be grown successfully. In order to shorten the time of rotation Weber and Ramsey[20] recommended a summer fallow, in which the land is plowed, cultivated, and kept bare of vegetation all summer. This method is quite severe on soil fertility, but he suggested a modification in which velvet beans could be planted and kept well cultivated as a cover crop. Under Philippine conditions, and especially in regions where there is a distinct dry hot season, the summer fallow method suggested by Weber might be adopted if two or three years of crop rotation cannot be followed.

Other control measures.—The selection and development of resistant varieties to control nematode infection offer a great field for investigation and would be the best method of control if resistant strains could be developed. Other methods, such as flooding the infected soil for two to four months, or plowing infested lands during the dry hot months in order to desiccate the nematode, are worthy of consideration. As important as are the methods above enumerated, the eradication of weeds, a clean culture, and the prevention of a promiscuous introduction of the pest from one locality to another through nursery stocks, or dirt which accompany propagating seedlings, should not be overlooked. The spread of the disease from one field to another should be avoided by proper precaution in the use of irrigation water, tools, plows, and work animals. A man's shoes should be cleaned or disinfected before he moves from an infested field to one free from the nematode.

SUMMARY

1. The root-knot nematode, *Heterodera radicicola*, is common and widespread in the Philippines, but thus far it is not so serious as to limit the production of the important truck and field crops.

2. Characteristic symptoms of plants infected with nematode are described.

3. The root knot found on tomato, tobacco, and other plants in the Philippines is caused by the well-known *Heterodera radicicola* (Greef) Muller, and so far no evidence of biologic strains of *H. radicicola* has been found.

4. Susceptible plants are readily infected with root-knot disease when grown in nematode-infested soil.

5. Root-knot infection was obtained at any soil moisture capable of supporting plant growth. A high percentage of infection was obtained even when the soil was saturated with water, or kept relatively dry.

6. Flooding of infected soil for thirty-five to forty days did not kill all the nematodes but the percentage of infection was greatly decreased.

7. Experiments showed that nematode-infested soil may be freed from the pest by air desiccation for twenty-five to thirty-five days. The length of time necessary to free the infested soil seems to depend on the initial moisture content of the soil.

8. The larvæ are very sensitive and are killed within ten to fifteen minutes of drying in the laboratory. The larvæ of the younger stage died much quicker than those of the older stages. Young larvæ were killed after three minutes of complete drying in the laboratory.

9. The larvæ suspended in water or kept in moist condition were found to survive much longer without food. Living larvæ were still observed after thirty-five days in water suspension under laboratory conditions.

10. Under Philippine conditions the root-knot nematode remains active all the year round. Root-knot infection can be produced at any time of the year from infected soil exposed to outside condition throughout the season.

11. All the American and Philippine tomatoes tested are susceptible to the root-knot nematode. Some varieties showed more resistance than the others, but the wild, small-fruited type and a few of the Philippine tomatoes are in general more resistant than the fleshy-fruited varieties.

12. The source of tomato seeds of a certain variety did not show any difference in their relative susceptibility.

13. Several common economic crops and weed plants in the Philippines are found susceptible to the root-knot nematode, and reported here for the first time. Rice, corn, garlic, onions, sincamas and seguidilla are found to be highly resistant to root-knot nematode.

14. No experiments on control measures were undertaken, but the already known control measures are suggested and discussed.

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ILLUSTRATIONS

PLATE 1

Root-knot symptoms on the roots of tomato and a weed, *Phaseolus lathyroides*, which are naturally infected in the field with the root-knot nematode.

FIG. 1. Mature tomato plant.
2. *Phaseolus lathyroides* Linn.

PLATE 2

Root-knot symptoms on the roots of tobacco, sitao, and garden beet plants.

FIG. 1. Tobacco.
2. Sitao.
3. Garden beet.

PLATE 3

Tobacco plant artificially infected in the greenhouse with the root-knot nematode, fifty days after inoculation. The main and secondary roots show swelling.

PLATE 4

Tobacco plants naturally infected in the field with the root-knot nematode. These plants were obtained from San Jacinto, Pangasinan Province, Luzon.

PLATE 5

Morphological stages of the root-knot nematode, *H. radicicola* (Greef) Muller. With the exception of the mature male nematode, all drawings were made with the aid of the camera lucida.

FIG. 1. Mature male, drawn under a low-power lens; about $\times$ 170.
2. Mature female, about $\times$ 73.
3. Egg sack, about $\times$ 73.
4. Various stages, *a, b, c, d,* in the development of the egg, about $\times$ 280.
5. Young larvæ, about $\times$ 170.

FIGS. 6 to 10. Various stages in the development of the female nematode. Fig. 10, the mature female, is about $\times$ 70; the others are about $\times$ 100.

PLATE 6

Photographs showing the relative susceptibility or resistance of tomatoes to the root-knot nematode; forty days after planting, about one-fifth natural size.

FIG. 1. Break o'Day.
2. Chalk's Early Jewel.
3. Dwarf Stone.
4. True Giant Ponderosa.
5. Yellow Plum variety.

PLATE 7

Photograph of tomato varieties, resistant and very susceptible to the root-knot nematode. Ten plants; forty days from date of planting, about one-third natural size.

FIG. 1. Break o'Day.
2. Chalk's Early Jewel.
3. Dwarf Stone.

PLATE 8

The two susceptible tomato varieties shown in Plate 7, slightly less than natural size.

FIG. 1. Break o'Day.
2. Dwarf Stone.

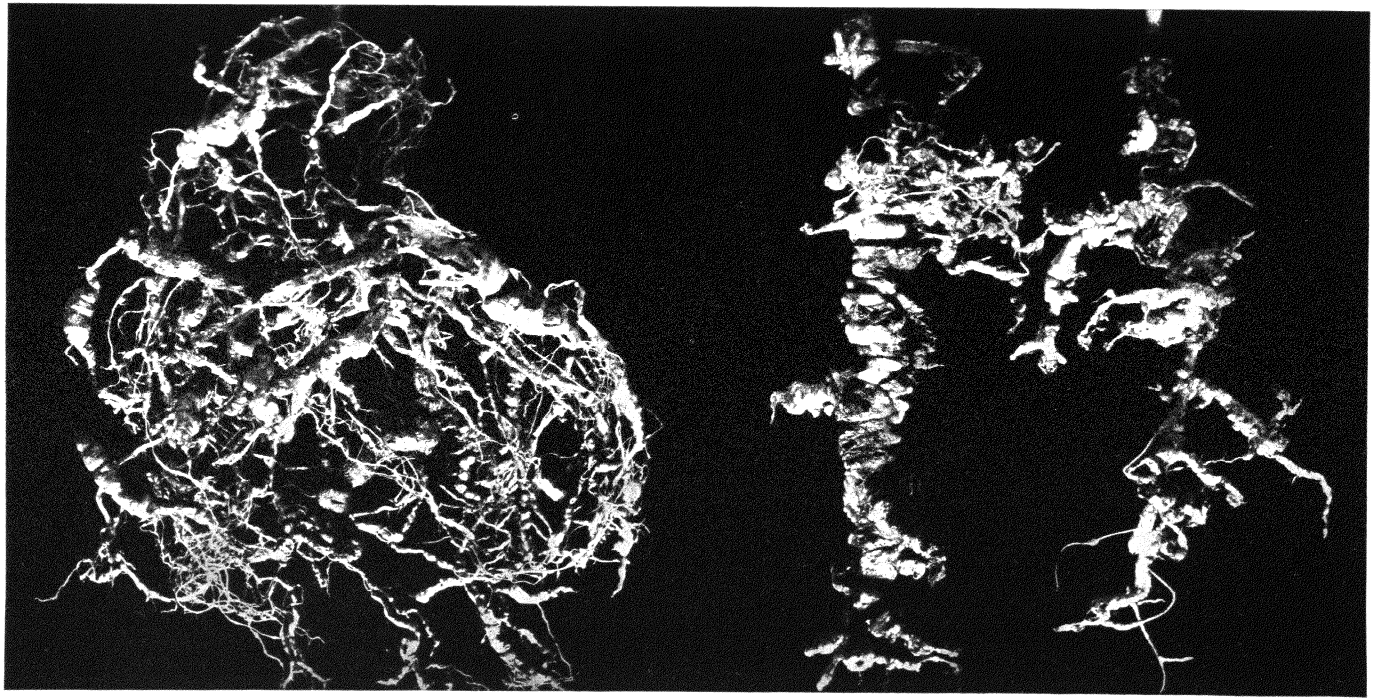

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PLATE 1.

PLATE 2.

PLATE 3.

PLATE 4.

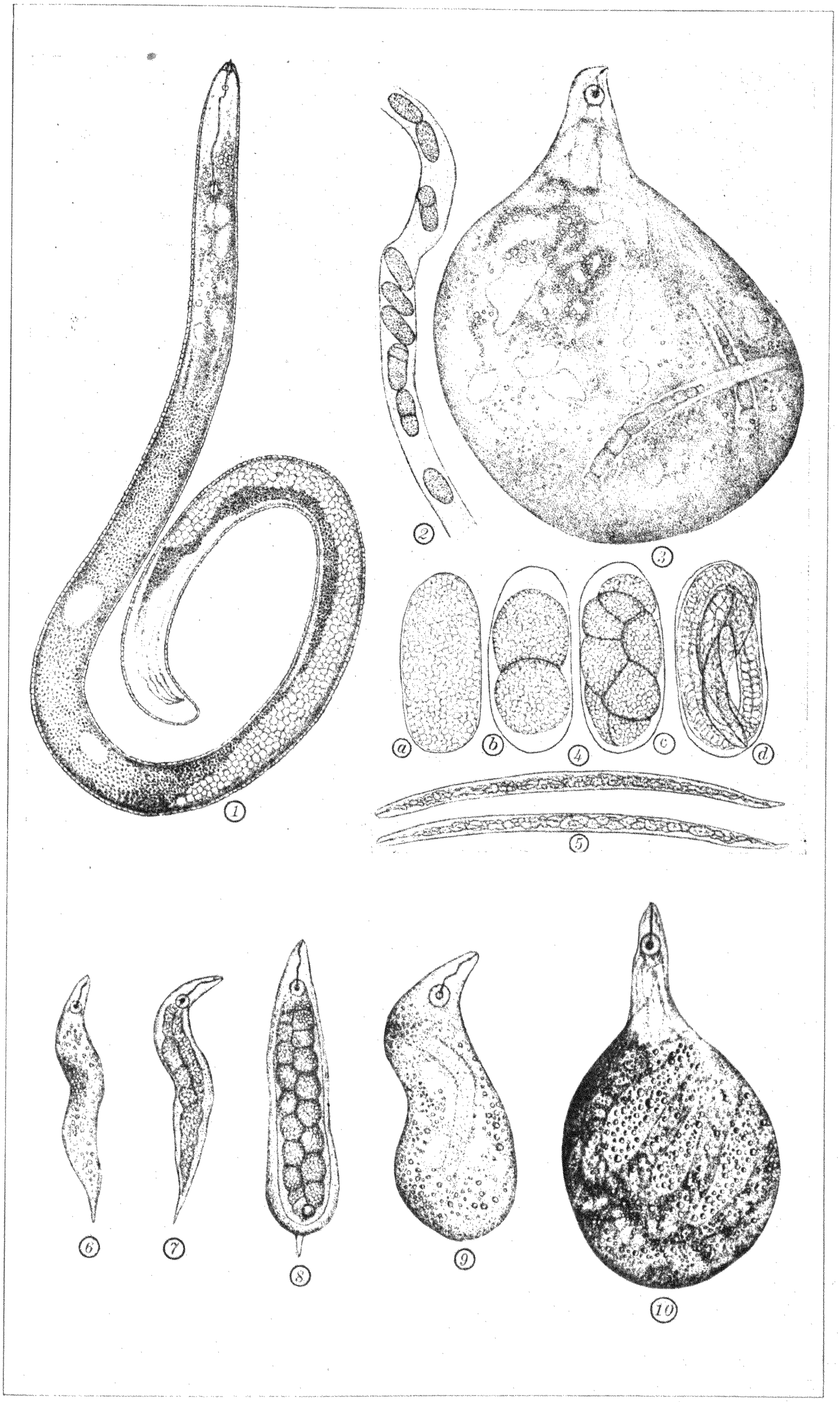
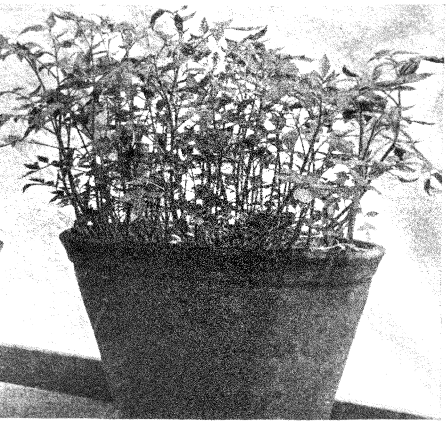


PLATE 5.

1



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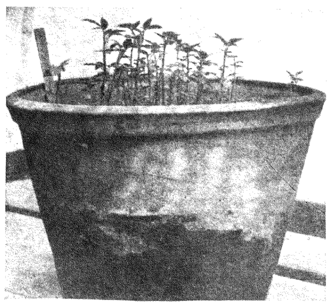
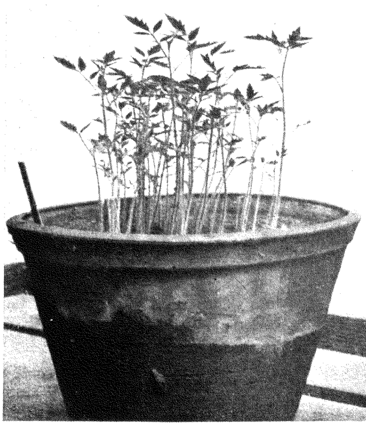


3



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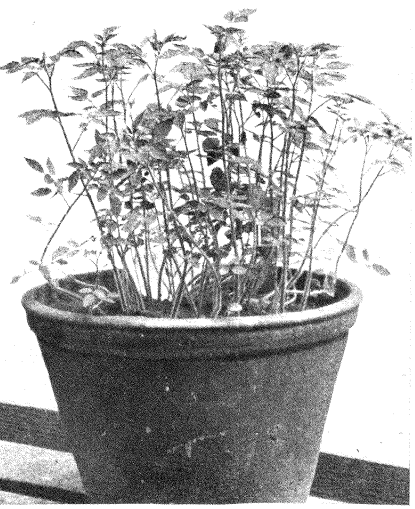

5

PLATE 6.

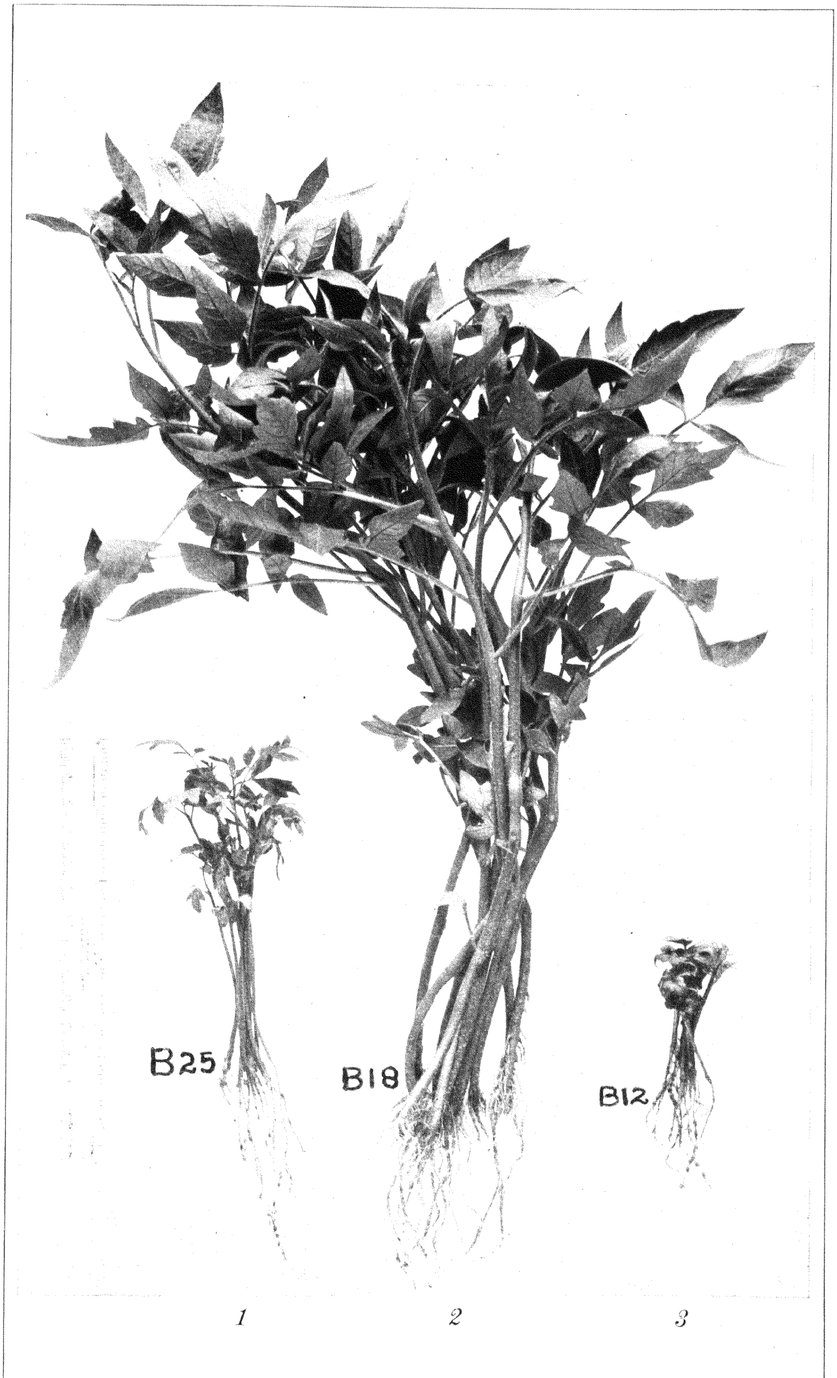

PLATE 7.

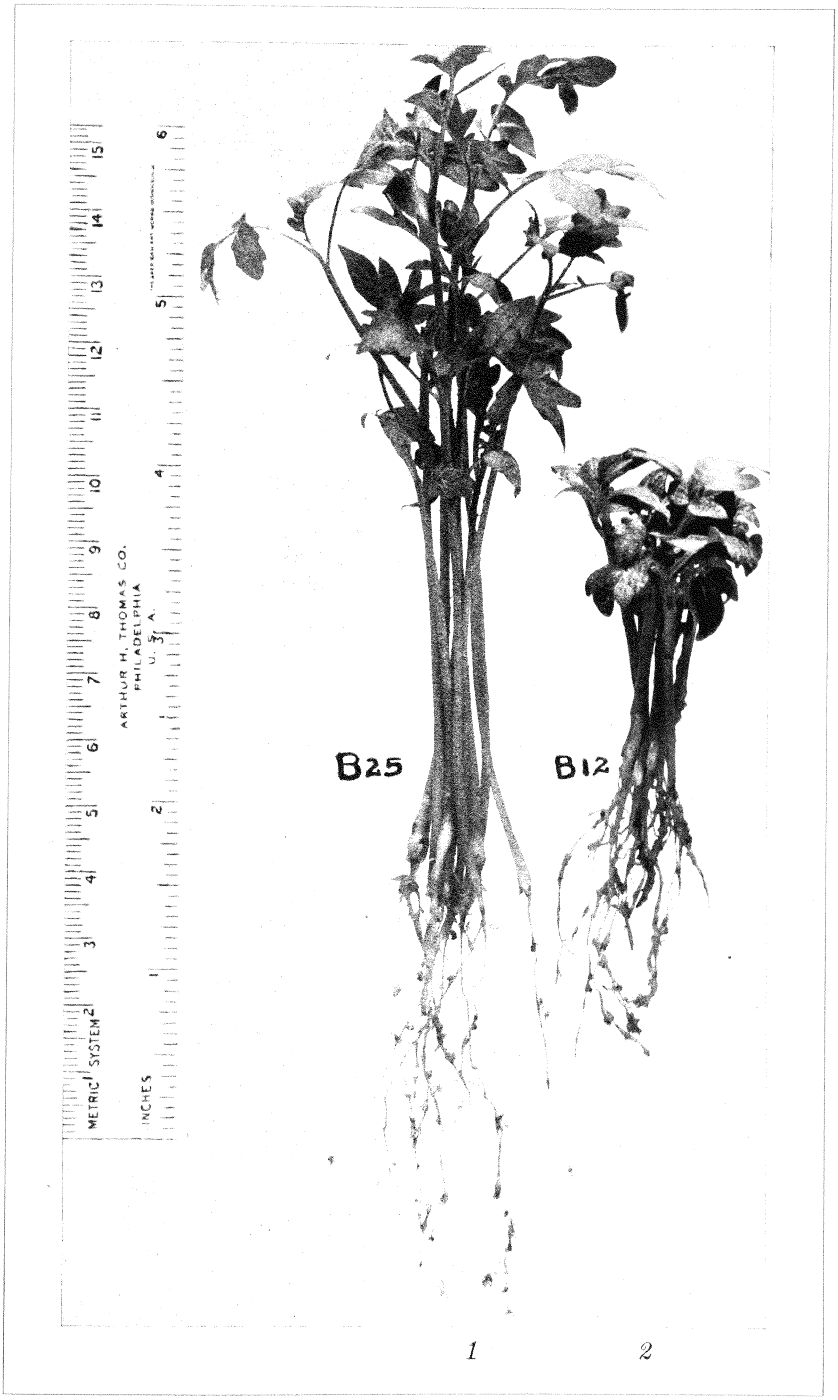

PLATE 8.

THE CATHARTIC EFFECTS IN MAN OF THE LEAVES OF WIKSTROEMIA OVATA MEYER (SALAGO LEAVES)

By Faustino Garcia

Of the Department of Pharmacology, College of Medicine University of the Philippines, Manila

Wikstroemia ovata Meyer(1) is a plant known locally by the name of "salago" in Tagalog; "malasampaga" in Pampango; "arandon" in Ilocano; and "dapnit" or "suka" in Bontoc. It is found growing in thickets and primary or secondary forests at low and medium altitudes in Luzon, Negros, and Mindanao. In Luzon, it is scattered in Bontoc, Benguet, Bulacan, Pampanga, Bataan, Rizal, Laguna, Batangas, and Sorsogon Provinces. Blanco(2) described it under the names *Daphne phoetida* and *D. indica*. His descriptions of the plants and their uses are as follows:

Daphne Phoetida. Dafne fetida. Tronco con las ramas medio ahorquilladas. Hojas opuestas, algo acorazonadas aovadas, muy aguzadas enteras y lampiñas. Peciolo cortísimo, y arriba con un canal alado. Flores terminales, en umbela simple. Involucro de la umbela, ninguno. Cal. ninguno, a no ser que se quiera llamar caliz a la corola. Cor. tubulada carnosa, tosca, de color verdecino, y el limbo con cuatro lacinias. Estam. ocho, fijos en las paredes de la corola, y colocados en dos series, esto es, cuatro en la garganta, y los otros alternos más abajo. Filam. cortísimos. Ant. asaeteadas. Germen cilíndrico, rodeado de dos escamas pequeñas hendidas en los extremos. Estilo ninguno. Estigma globoso. Baya superior, con una semilla globosa, con la corteza coriacea y delgada. = Estos arbolitos menores que el brazo, se elevan a la altura de nueve pies. Los indios generalmente conocen el *Salago,* aunque algunas veces enseñan una cosa por otra. Son comunes en las playas del mar. Su corteza es tenacísima, y he visto que se puede hacer facilmente papel de ella. Para esto basta hecharla en agua, y sacarla al día siguiente o a los dos días. Se vuelva al agua después de seca, y se la pisa bien con los pies, y se deja secar al sol. Esta operación se continuará por algunos días, hasta que el material tome la blancura que se desea. Aunque creo no ser necesario, por lo que yo he experimentado, molerle en molinos, siempre será bueno hacerlo, para lograr una mayor y más perfecta división. Este tiene el color ceniciento, y no se podrá blanquear más. Las hojas se usan con efectos muy satisfactorios para purgar: y sobre esto tanto en el número de ellas, como

en el modo de arrancarlas, forman los indios varias supersticiones. Las hojas según ellos, no se pueden tomar sino en numero impar: y si se arrancan hacia abajo, toda la operación será por abajo: y por vómito, si se arrancan tirando hacia arriba: se toman en peso de doce granos, o la cuarta parte de una dracma, mezclados sus polvos en el chocolate, o con miga de pan, y se hacen píldoras. Los indios de Tanawan, creen que se alivia la papera enfermedad común en aquel y algun otro Pueblo de Batangas, ciñéndola con una cinta de la corteza del arbolito. Flr. en Jun. T. Salago, Malasampaga.

Daphne Indica. Dafne de indias., Hojas opuestas aovadas alargadas, aguzadas enteras y lampiñas. Peciolos cortísimos con canal un poco alado. Flores terminales en umbela, Cor. de color amarillo, de figura de embudo, arqueada, con cuatro lacinias lanceoladas. Estam. como en la especie anterior. Anteras encarnadas. Estilo corto. Lo demás como en la especie anterior. = Arbolitos conocidos en Bulacán, y cuyas hojas sirven para purgar, como dije antes: las flores no son feas como las del anterior salago. T. Salago, Malasampaga.

According to Merrill(3) both species described by Blanco, under the names *Daphne foetida* and *D. indica*, were manifestly *Wikstroemia ovata* Meyer.

From the book of Blanco it can be seen that this plant "salago," or *Wikstroemia ovata,* has been used by the natives as a purgative even before 1837. According to Juan Tolentino, of Mesulao, Calumpit, Bulacan, the first one who mentioned the cathartic property of the plant to me, the leaves are a strong purgative when chewed and swallowed and one bowel movement is produced for every leaf taken. All other properties cited by Blanco were known to him. To verify and study more about the cathartic property of the leaves of *Wikstroemia ovata,* commonly known as salago, this investigation was carried out. The specimens that were used for investigation were supplied me partly by Mr. Juan Tolentino and mainly by Dr. E. Quisumbing and were identified as *Wikstroemia ovata* by Drs. Leon M. Guerrero and E. Quisumbing, of the Bureau of Science.

THE EFFECTS OF "SALAGO" LEAVES IN MAN

The dose advised by Blanco as a cathartic is from 0.8 to 1.0 gram of the dried powdered leaves taken mixed with chocolate or bread. As the weight of a large matured green leaf is about 0.15 to 0.18 gram and, on drying, it is generally reduced to one-half or one-third of its weight, five green leaves would be within the dose recommended by Blanco. Believing that five leaves or less when chewed and swallowed would produce only catharsis

in man I tried them on volunteers. Three subjects presented themselves, and to each of them I gave five green leaves which they chewed and swallowed, followed by a glass of water. The expected catharsis was produced, but the tenesmus and other side effects were so great that none of the three would take the leaves again. In subsequent experiments, the dose was reduced; and with the help of medical students, who at the beginning were skeptical about my statement with reference to the cathartic property of the leaves, I was able to obtain results of different doses. The effects were qualitatively similar but quantitatively different depending upon the dosage. The following case may serve as an illustration of the usual effects of the green leaves:

G. N. D., adult medical student, weighing 45 kilograms; habitual bowel movement every second or third day. Bowel movement the morning of January 8, 1932, and none the next morning. January 9, 1932, at 10.11 a. m., he chewed and swallowed four green leaves with a total weight of 0.4 gram followed by a glass of water.

10.16 a. m., warm and biting sensation in the mouth and throat and slight numbness at the tip of the tongue, which increased in intensity to a burning, sharp, biting taste with some numbness two hours after, persisted and then gradually diminished until it disappeared at about 6.10 p. m. The numbness persisted until the next morning.

11.25 a. m., slight stomachache with perspiration. Eructation and flatus occurred, gurgling sounds; uneasiness and bodily weakness were felt. These symptoms continued at intervals throughout the afternoon.

12 noon, first bowel movement; stool composed of small, pill-like, solid fæces.

12.20 p. m., took his usual luncheon.

12.35 p. m., second bowel movement; a large amount of watery stool, preceded by slight tenesmus and sensation of heat in the anus during defecation.

1.25 p. m., third bowel movement, greenish watery stool, less in amount than in the second bowel movement. Slight tenesmus was present.

2.15 p. m. fourth bowel movement, similar to stool in the third but scanty in amount.

6.30 p. m., slight stomachache and accompanying symptoms.

7.20 p. m., took his dinner.

7.40 p. m., felt all right again, the same as before taking the leaves.

January 10, 1932, no bowel movement.

January 11, 1932, one bowel movement of soft but formed stool.

January 12, 1932, no bowel movement.

Similar effects were obtained in other cases with more or less intensity depending upon the dose. For convenience of discussion the cathartic effects of different doses of green leaves in twelve subjects are given in Table 1.

TABLE 1.—*Cathartic effects of green salago leaves in man, chewed and swallowed.*

Subject's initials.	Weight of subject.	Dose.	Matured, large and medium-sized, green leaves.	Time of administration.	
	kg.	*g.*		*a. m.*	*p. m.*
F. G	56	0.15	1	-----	1.29
A. A. P	60	0.28	2	10.50	----
R. J. B	46	0.30	2	10.46	----
A. S	57	0.30	2	11.47	----
J. T	52	0.40	4	10.10	----
G. N. D	45	0.40	4	10.11	----
J. N. A	50	0.50	3	10.49	----
M. G. B	81	0.62	4	10.43	----
J. C	65	0.70	4	10.50	----
J. K. J	75	0.80	5	-----	1.53
L. P	60	0.85	5	-----	1.25
P. S	51	0.85	5	-----	1.42

Subject's initials.	Time of action.		Bowel movements.	Duration of action. Time between first and last cathartic bowel movement.		Remarks. All leaves pulled upward on picking.
	Hrs.	*mins.*		*Hrs.*	*mins.*	
F. G	17	41	1	--	--	In addition one bowel movement at usual time.
A. A. P	6	10	2	13	00	
R. J. B	5	6	1	--	--	
A. S	1	28	1	--	--	
J. T	2	10	3	5	00	
G. N. D	1	49	4	2	15	
J. N. A	1	41	3	1	30	
M. G. B	1	32	3	1	00	
J. C	1	50	5	5	50	Very slight blood stain and much mucus in stool.
J. K. J	7	37	4	10	00	
L. P	6	15	5	13	50	
P. S	1	48	5	14	00	Vomited twice.

A glance at Table 1 shows that increasing the dosage increased the number of bowel movements produced, but apparently there is no tendency to produce one bowel movement for every 0.15 gram of the leaves. The relation is more in favor of almost one bowel movement for every leaf taken. This relation would naturally be affected by the weight or resistance of the patient. For instance, there was one whose weight was 81 kilograms who chewed and swallowed four large green leaves weighing 0.62 gram and produced only three bowel movements.

On the other hand one whose weight was 45 kilograms, chewing the same number of leaves but with less weight or 0.4 gram produced four bowel movements. Considering the dose by the leaves it will be seen that in the three subjects who took five leaves, five bowel movements were produced in two and four in one; of the four who chewed four leaves of different sizes, two produced three bowel movements, one produced four, and one produced five bowel movements; the average was almost four bowel movements; one took three leaves and produced three bowel movements; of three who chewed two leaves, one produced two bowel movements and two one bowel movement plus the ordinary bowel movement the next morning. With one leaf the effect was delayed and seemed to increase only the normal bowel movement by one at the usual time of defecation. For practical purposes, therefore, it may be stated that one bowel movement was produced for every large green leaf taken. The time of action has some relation to the time of administration. With three to four leaves taken one to two hours before a meal, the usual time of response was from one and one-half to two hours. With smaller doses, one to two leaves, the time of cathartic response was delayed from five to seventeen hours. Taken one to two hours after a heavy meal, the time of action was delayed from two to seven hours even with large doses. The duration of the cathartic action varied with different doses. In general, doses of three to four leaves with weights from 0.4 to 0.6 gram produced catharsis within from one to five hours, and with larger doses the duration was prolonged from ten to fourteen hours. The stools were all watery except the first bowel movement, which might be formed at the beginning and soft or watery at the last part. The quantity was generally much in the first and second stools and scanty at the later bowel movements.

Side effects.—Disagreeable abdominal sensations, similar to those of hunger, occurred at intervals and caused slight perspiration, bodily weakness, and uneasiness rather than pain, and slight tenesmus just before defecation; these were frequent manifestations in all cases. These effects and those produced on the mouth and throat were the side effects disliked by all who took the leaves. The effects on the mouth and throat were qualitatively similar in all cases even with small doses but quantitatively different, and the quantitative variation was due probably to the length of mastication one employed before swallowing.

These effects consisted of warm to burning sensation in the mouth and throat, sharp, biting or pungent taste, and some feeling of numbness, especially at the tip of the tongue. All were present from a few minutes after chewing, and gradually became more intense until two to three hours after, gradually subsided and disappeared in ten to eighteen hours after mastication. With large doses, one patient vomited twice during the height of catharsis and in another a slight stain of blood and much mucus were observed in the first bowel movement but were absent in subsequent bowel movements. The catharsis produced by large doses was so great that one of the subjects could not delay defecation long enough to reach the toilet.

It is not true, as indicated in the literature, that leaves pulled upward in picking will cause vomiting. All the leaves used in my experiments were picked by being pulled upward and still all the effects were catharsis, and only in one instance a large dose produced both vomiting and catharsis.

CORRECTION OF SIDE EFFECTS

To avoid the disagreeable effects on the mouth, the leaves were sliced and placed in capsules before administration. To correct the mild colic or abdominal pain belladonna powder was administered at the same time. Administration of the leaves in capsules completely eliminated the disagreeable effects on the mouth and throat, but the cathartic actions were modified, as shown in Table 2.

When the leaves were cut in big slices 2 millimeters or more wide, placed in capsules, and then administered by mouth, the cathartic effects were not manifested with doses that would surely have been effective if the leaves had been chewed and swallowed as indicated in previous experiments and in the control shown in Table 2. If the leaves, however, were cut into fine slices 1 millimeter or less in width, placed in capsules, and similarly administered by mouth some modified cathartic effects were produced. The cathartic effects were less in general compared with similar doses of leaves that were chewed and swallowed. The time of action was delayed in nearly all subjects who took the leaves with belladonna powder and the duration of its action was generally prolonged in several cases. The number of bowel movements produced has no relation to the

doses given as in the cases of those who chewed and swallowed the leaves. Belladonna powder did not lessen the abdominal pain that usually preceded or accompanied the cathartic effects of the leaves.

TABLE 2.—*Influence of capsules, size of slices, and belladonna powder on the effects of salago leaves.*

Subject's initials.	Weight of subject.	Dose.	Leaves.	Time of administration.
	kg.	*g.*		*a. m.*
M. B	58	0.42	3	9.35
J. B	45	0.53	4	9.40
L. S	57	0.58	4	9.43
F. G	56	0.37	3	11.01
J. B	45	0.35	3	9.36
M. B	58	0.4	3	9.37
V. G. B	53	0.26	2	11.44
J. C	65	0.3	2	11.40
J. R. A	48	0.4	3	11.44
D. J. A	50	0.48	3	11.42
J. A	48	0.45	3	11.03
M. B	58	0.52	4	11.30
A. J	47	0.60	4	11.02
V. A. F	62	0.65	4	11.05

Subject's initials.	Time of action.		Bowel movements.	Duration of action.		Remarks.
	Hrs.	*mins.*		*Hrs.*	*mins.*	
M. B	----	----	0	----	----	Big slices in capsules.
J. B	----	----	0	----	----	Do.
L. S	----	----	0	----	----	Do.
F. G	----	----	0	----	----	Big slices in capsules with belladonna.
J. B	1	57	2	8	31	Leaves chewed and swallowed.
M. B	4	01	3	3	40	Do.
V. G. B	----	----	--------	----	----	Fine slices in capsules.
J. C	1	50	2	2	30	Do.
J. R. A	1	56	4	17	30	Do.
D. J. A	3	59	2	4	29	Do.
J. A	16	0	3	0	50	Fine slices in capsules with belladonna powder. Abdominal pain present as without belladonna.
M. B.	13	0	2	10	30	Fine slices in capsules with belladonna powder. Abdominal pain present as without belladonna. Stomach pain, sensation of fullness one hour and five hours after.
A. J	20	58	1	----	----	Abdominal pain.
V. A. F	10	10	3	9	4	Abdominal pain, eructation, and headache.

IS THE ACTIVE PRINCIPLE PRESERVED ON DRYING?

"Salago" leaves were allowed to dry in the laboratory room and the weight was found to be reduced from 0.28 gram of the green leaves to 0.1 gram of the dried. These dried leaves were used in the experiments by chewing and swallowing, at different intervals, and the results obtained are given in Table 3.

TABLE 3.—*Effects in man of dried "salago" leaves chewed and swallowed.*

Subject's initials.	Weight.	Time of drying.	Dose.	Leaves.	Time of administration.	Time of action.		Bowel movements within 18 hours after administration.	Remarks.
	kg.	*Days.*	*g.*		*a. m.*	*Hrs.*	*mins.*		
J. B.	45	15	0.15	3	9.40	3	0	1	Diarrhœic stool; usual bowel movement next day; usual sensation in mouth.
A. P.	62	15	0.18	3	9.40	0	35	2	Diarrhœic stool; usual sensation in mouth.
M. B.	58	15	0.25	5	9.41	3	2	3	Watery stool.
D. J. A.	50	22	0.1	3	10.39	----	----	0	Only bitting and warm sensation in mouth.
S. A. D.	56	22	0.2	4	10.42	2	21	4	Watery stool.
F. G.	57	44	0.27	5	10.11	2	56	1	Watery stool; usual bowel movement next day and warm sensation in mouth.
		Years.							
F. C.	52	2	0.14	3	10.50	----	----	0	Slight warm sensation in mouth that lasted about one-half to 2 hours.
A. C. T.	53	2	0.2	4	10.10	----	----	0	Do.
F. L.	45	2	0.2	4	10.10	----	----	0	Do

Judging from the data in Table 3, one will conclude that the activity of the leaves is decreased or lost upon drying. Three to five leaves, which ordinarily when taken fresh moved the bowels from three to five times, produced fewer or no movements, depending upon the length of time of drying. There was slight or no diminution with fifteen to twenty-two days drying, distinct reduction with forty-four days, and total loss of activity in causing catharsis with 2-year-old dried

leaves with doses of 0.2 gram equivalent to at least 0.58 gram of green leaves. The effect on the mouth was still present but greatly reduced, indicating that the active principle, at least that causing warm sensation in the mouth, was not completely lost on two years drying, but what was left in the dose given was not sufficient to cause catharsis. On account of the variable effects of the dried leaves and in view of the fact that it was difficult to obtain always fresh material for experiments when needed, the chemical and pharmacodynamic studies were rendered difficult. Studies are being continued along these lines.

SUMMARY AND CONCLUSIONS

1. The green leaves of *Wikstroemia ovata* Meyer (salago leaves) when chewed and swallowed produced varying degrees of catharsis, depending upon the number of leaves taken. In general it may be stated that every large leaf caused one watery bowel movement.

2. One to two large leaves of "salago" chewed and swallowed, caused generally one to two laxative or purgative effects, and three to four leaves, weighing from 0.4 to 0.6 gram produced three to four watery stools apparently drastic in character. The therapeutic cathartic doses may be placed between one and four leaves, inclusive, or 0.15 to 0.65 gram. Five large leaves, weighing at least 0.8 gram, produced not only catharsis but in some cases vomiting and other pronounced side effects.

3. The side effects noted were the effects on the mouth and throat when leaves were masticated and consisted of a warm to burning sensation and pungent and biting taste, mingled, later, with numbness. These effects were intensified in two to three hours and then gradually subsided in ten to sixteen hours. Eructation and flatus frequently occurred in one to two hours or more before the cathartic effect. Sensation of fullness in the abdomen, slight abdominal pain occurring at intervals, mild tenesmus, perspiration, and bodily weakness were the frequent complaints of the subjects.

4. The undesirable effects on the mouth and throat could be avoided by administration of the leaves in capsules, but in this form of administration the cathartic effects were uncertain. The abdominal pain and tenesmus were apparently not mitigated by the administration of therapeutic dose of belladonna.

5. The cathartic active principle was partly or mainly lost during desiccation at room temperature and in keeping the

leaves in the dried form. Some of it was still left after two years, enough to give distinctly the usual effect on the mouth when chewed, but not enough to produce catharsis as when freshly taken. The deterioration of the active principle in drying and keeping rendered the chemical and pharmacodynamic studies difficult on account of the lack of fresh material when needed.

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3. MERRILL, E. D. Species Blancoanae. Bureau of Science, Manila (1918) 279.

NEUE CASSIDINEN VON DEN PHILIPPINEN-INSELN (COLEOPTERA; CHRYSOMELIDÆ)

Von FRANZ SPAETH
Vienna, Austria

PRIOPTERA LATISSIMA Wagen. POLILLOENSIS subsp. nov.

Auf Polillo hat Herr W. Schultze ein Männchen einer *Prioptera* gesammelt, das ich für eine sehr interessante Abart der *P. latissima* halte. Auf jeder Flügeldecke sind vier schwarze Flecke: der 1. rund und ziemlich gross, vorne neben der Naht and Höckerstelle, schräg vor dem grossen Hauptgrübchen; bei der Nominatform fehlt er oder ist viel kleiner; ich habe schon seinerzeit in meiner Revision der Gattung *Prioptera* [1] aufmerksam gemacht, dass im Gegensatz zu anderen Arten dieser Fleck bei *latissima* nicht in, sondern vor dem Hauptgrübchen steht, und es ist daher ein Beweis für die Zugehörigkeit der vorliegenden Unterform zu *latissima,* dass dieser Fleck auch bei ihr hauptsächlich vor und nur mit einem kleinen Teil in der Grube steht. Der 2. Fleck ist kleiner, mehr quer, genau hinter dem ersten auf dem Abfall; dieser Fleck fehlt bei der Nominatform ganz. Der 3. ist genau wie bei dieser gebildet und gestellt: strichfömig, halb verloschen, aussen vom dritten Grübchen, im drittletzten Zwischenraum; der 4. ist eine bis an den Aussenrand reichende Querbinde hinter der Mitte des Seitendaches, eine Vergrösserung des dort bei der Nominatform vorkommenden, kleinen Fleckes.

In der Körperform und Skulptur, insbesonders der vorderen, tiefen Ausrandung des Halsschildes und der feinen, gleichmässigen Punktierung der Flügeldecken, stimmt *polilloensis* ganz mit der Nominatform überein.[2]

[1] Philip. Journ. Sci. 28 (1925) 414. Dort steht auf p. 414 infolge eines Korrekturfehlers in der 15. und 24. Zeile von oben irrtümlich statt "und zwar"-"und zuweilen;" derselbe Fehler ist auch p. 407, 11. Zeile von unten.

[2] Ich benütze die Gelegenheit der vorstehenden Publikation in The Philippine Journal of Science, die dort erschienene obige Revision der Gattung *Prioptera* durch die folgende Beschreibung einer neuen *Prioptera* zu ergänzen.

PRIOPTERA LAOTICA sp. nov.

Obtriangularis, modice convexa, nitida, albidoflava, subtus cum antennis et pedibus laete testacea, prosterno, pectore medio, capite, antennarum articulo ultimo, denique vitta transversa pone medium protecti nigris; prothorax laevis, antice late, minus profunde emarginatus; elytra prothorace basi haud latiora, lateribus ultra medium sensim rotundatoampliata, disco non gibbosa, mediocriter et subregulariter punctatostriata, protecto laevi.

Mas magis rotundatus, brevior, antennis longioribus, articulo ultimo longiore et crassiore, apice ciliato; long. 8, lat. 7 mm.

Femina minus rotundata, antennis brevioribus, articulo ultimo breviore; long. 8, lat. 7 mm.

Tonkin, Lao-Kai.

Mässig gewölbt, oben stark glänzend, weisslichgelb, unten gesättigter gelb; das Prosternum, die Mitte der Brust, der Kopf, das letzte Fühlerglied und eine schmale Querbinde hinter der Mitte des Seitendaches sind schwarz. Die grösste Breite liegt kurz vor ihr, von wo die Flügeldecken zur Basis verengt sind, wo sie die gleiche Breite wie der Halsschild haben. *Prioptera laotica* ist nur mit *prognata* m. von Darjeeling nahe verwandt, hat die ganz gleiche Körperform und Zeichnung und unterscheidet sich von ihr durch ihr breiteres Seitendach, mehr gerundet verlaufende Seiten (zum Vergleiche dient das Weibchen, da ich von *prognata* nur dieses kenne) etwas schlankere, dünnere Fühler, besonders aber durch die zwar auch in unregelmässigen, verworrenen Streifen, aber viel feiner, weniger runzelig und dicht punktierten Flügeldecken; bei *prognata* sind die Zwischenräume schmäler als die Streifen, zum Teil herausgewölbt und die Punkte der mittleren Streifen (3 bis 7) greifen, besonders in den Grübchen, ineinander über, bei *laotica* ist letzteres nicht der Fall, die Punkte sind feiner, und stehen weniger dicht, die Zwischenräume sind vielmals breiter und es können die Streifen überall, auch in den Grübchen, getrennt verfolgt werden. Die Spitze der Epipleuren ist in beiden Geschlechtern fein und lang behaart.

Wollte man *P. laotica* nach meiner Tabelle[3] bestimmen, so würde man auf *prognata* gelangen.

Vier Stücke sind in meiner Sammlung.

LACCOPTERA SCHULTZEI sp. nov.

Subtriangularis, subnitida, gibbosa; subtus flavotestacea, pectore nigro, antennis basi flavotestaceis, articulis 4 ultimis nigres-

[3] Philip. Journ. Sci. 28 (1925) 381.

centibus, supra testacea, protecto prothoracis dilutiore, protecto elytrorum hyalino, albido, ramis duobus utrinque apiceque testaceis, gibbere maculisque nonnulis disci indistinctis picescentibus; prothorax ad basim haud angustatus, disco sat profunde longitudinaliter aciculato; elytra prothorace fere duplo latiora, humeris subacutis, gibbere sat alto, antice posticeque sat profunde emarginato, disco subregulariter punctato-striato, interstitiis alternis, imprimis secundo subcarinatis, protecto in ramis profundius rugoso-punctato; unguiculi intus tantum pectinati; long. 10, lat. 9 mm.

MINDORO, Abra de Ilog (*W. Schultze*).

Von fast dreieckigem Umriss, in den Schultern am breitesten, von hier nach hinten fast geradlinig verengt, beinahe zugespitzt, nur das äusserste Ende verrundet. Unten braungelb, die Brust (ohne Seitenteile) schwarz; letztere Farbe haben auch die vier letzten Fühlerglieder. Oberseite gelbbraun, das Vordach des Halsschildes und das Seitendach durchscheinend weissgelb, letzteres mit zwei breiten hellbraunen Randästen, einer ganz an der Basis, der andere hinter der Mitte; die Höckerstelle ist etwas dunkler; auf den höheren (primären) Zwischenräumen sind hinter der Mitte einige braune Flecken.

Halsschild nur halb so breit als die Basis der Flügeldecken, vorne flach gerundet, die Seiten nach hinten kaum verengt, die Scheibe mit ziemlich tiefen und langen Längsrissen, das Vordach mit einigen, unscharfen Falten. Flügeldecken mit wenig vortretenden, aber seitlich weit abstehenden, spitzwinkligen, kaum abgestumpften Schulterecken. Das Basaldreieck ist schwach eingedrückt, der Höcker hinter ihm hoch und spitzig, die Profillinie vor und hinter ihm ziemlich tief konkav ausgerandet. Die Punktstreifen sind grob, ineinander undeutlich übergreifend; die alternierenden (primären) Zwischenräume, besonders der 2. und 4. sind höher, der 2. durch eine hohe Querleiste mit dem Höcker, dahinter durch eine viel niedrigere mit dem 4. Zwischenraum verbunden. Das Seitendach ist auf den Randästen sehr tief, narbig, auf den durchscheinenden Stellen, besonders innen viel feiner punktiert. Die Klauen sind innen ziemlich lang gekämmt, aussen undeutlich gerieft.

Laccoptera schultzei ist der *quadripunctata,* die über das ganze südliche China bis zur Spitze von Vorder Indien verbreitet ist, zunächst verwandt, unterscheidet sich aber durch die viel grössere Gestalt, höheren Höcker, tiefer ausgerandete Profillinie, nach hinten nicht verengten Halsschild mit gröber und länger rissiger Scheibe, seitlich weiter ausladende, spitzigere Schulter-

ecken, gröbere Punktstreifen mit höheren primären Zwischenräumen, gröber skulptiertes Seitendach.

Das einzige, der Beschreibung zugrunde liegende Stück wurde von Herrn W. Schultze gesammelt und ist in seiner Sammlung.

Auf den Philippinen sind bisher drei Arten *Laccoptera* aufgefunden worden:

a. Laccoptera tredecim-punctata F. Nur auf Palawan, wo sie von C. F. Baker bei Puerto Princesa gesammelt wurde.

b. Laccoptera philippinensis Blanch. Die letztere auf allen Inseln, besonders auf Luzon häufige Art wurde von Blanchard [4] beschrieben; eine genauere Beschreibung gab dann Boh. im III. Bande seiner Monographie 1855. Da Blanchard als Vaterland seiner Art, obwohl er sie *philippinensis* nannte, Sumatra angab, wo die hier in Betracht kommende Art nicht vorkommt, änderte ich den Namen in *luzonica;* [5] ich glaube jetzt aber, dass hiezu kein genügender Grund vorliegt, da Blanchard jedenfalls auch Stücke von den Philippinen vorlagen. *Laccoptera philippinensis* ist hinsichtlich der Punktierung der Flügeldecken und des Seitendaches sehr veränderlich; das reiche, mir in den letzten Jahren vorgelegene Material hat mich überzeugt, dass nicht nur die *L. 13-guttata* Wagen., deren Typus in meiner Sammlung ist, sondern auch die *manilensis* Wse., 1910, dieselbe Art sind. Die Synonymie ist daher:

LACCOPTERA PHILIPPINENSIS Blanch, 1853; Boh., 1855.

= *13-guttata* Wagen., 1881.
= *manilensis* Wse., 1910.
= *luzonica* nom. cat., 1914.
ab. *nigripennis* Wse., 1910.

c. Laccoptera schultzei sp. nov. Mindoro.

CASSIDA LUZONICA sp. nov.

Rotundata, nitida, rufotestacea, elytrorum disco nigromaculato et vittato; caput trapezoidale, planum, subpunctatum; prothorax subellipticus, antice minus quam postice rotundatus, longitudine vix duplo latior, disco vix punctulato; elytra latitudine parum longiora, basi leviter impressa, deinde subgibbosa et ruga parum elevata instructa, subregulariter punctatostriata; long. 6, lat. 5.25 mm.

LUZON, Ilocos Norte Province, Dungan-Dungan (W. Jark, mus. Hambg.); Burgos (coll. Schultze). Typus in mea collectione.

[4] Voy. Pôle Sud 4 (1853) 312.
[5] Junk-Schenkling, Coleop. Cat. pars 62 (1914) 82.

Rötlichgelb, mit wenig dunkleren Endgliedern der Fühler und schwarzer Zeichnung der Flügeldecken. Gewölbt, gerundet, mit der grössten Breite vor der Mitte der Flügeldecken, oben glänzend. Kopfschild trapezförmig, um mehr als die Hälfte länger als breit, mit flachem, glattem, glänzendem, lang dreieckigem Mittelfeld, das von feinen, konvergierenden Stirnlinien, die am Augenrande verlaufen, umsäumt wird. Die Fühler überragen wenig die Ecken des Halsschildes und haben 5 schwach verdickte und mattere Endglieder, die um die Hälfte länger als dick sind, das 3. Glied ist nur wenig länger als das 2.; die folgenden fast gleich lang.

Halsschild doppelt so breit als lang, elliptisch; hinten mehr als vorn gerundet; die abgerundeten Ecken liegen wenig vor der Längsmitte; die Oberseite ist sehr fein punktuliert. Die Flügeldecken sind an der Basis schwach ausgerandet, in den schräg, nicht ganz bis zur Mittellinie des Halsschildes vorgezogenen, spitzwinkligen, mässig scharfen Schulterecken fast ein Viertel breiter als der Halsschild, dahinter bis vor die Mitte sehr schwach erweitert, hinten breit verrundet; die Scheibe ist im Basaldreieck deutlich eingedrückt, dahinter undeutlich stumpf gehöckert; ihre Profillinie ist sehr stumpfwinklig gebrochen, hinten mit schwacher Neigung gerade abfallend; die Punktstreifen sind regelmässig, grob, aber nicht tief, ihre Zwischenräume innen breiter, aussen schmäler, stark glänzend, glatt, schwach gewölbt; die Höcker-Querleiste ist kräftig und gabelt sich am 2. Zwischenraum; sie ist gesättigter gelb als die übrige Scheibe und setzt sich in dieser Färbung auf dem hier breiteren zweiten Zwischenraum bis an die Basis fort; die schwarze Zeichnung besteht aus einer aussen von diesem Zwischenraum beginnenden Binde, die an der Basis quer über die Schulterbeule laufend, nach hinten biegt, aussen vom vorletzten Streif begrenzt wird, an der Seitendachbrücke bis zum 7. Streif tief ausgerandet ist und dann in Flecke aufgelöst, um die Scheibe hinten zur Naht zieht, wobei der letzte und hinten der vorletzte Zwischenraum, gelb bleiben; ausserdem sind der Höcker und einige Flecke innen, die eine aufgelöste Querbinde bilden, schwarz; die verbleibenden hellen Stellen sind sehr schwach überhöht; Seitendach breit, hinten nur wenig schmäler, glatt, mässig geneigt. Klauen ohne Zahn.

Cassida luzonica gehört zur Gruppe der *C. andrewesi* Wse., die in Südasien in zahlreichen Arten vertreten ist, welche zum Teil eine der *luzonica* ähnliche Zeichnung haben (*andrewesi, justa, gentilis* u. a.). Von den Philippinen ist aus dieser Gruppe

bisher nur eine Art, *C. abamita* m.[6] bekannt; diese ist der *luzonica* äusserst ähnlich, aber kleiner (5 mal 4.25 mm.), an den Seiten nicht erweitert, im Basaldreieck weniger tief eingedrückt, der Höcker schwächer, die Punktstreifen sind feiner, die schwarzen Zeichnungen auf eine hinten abgekürzte Längsbinde, die Höckerstelle und einen unscharfen Querwisch hinten reduziert; ferner ist der Kopfschild eingedrückt.

CASSIDA EXCÆCATA sp. nov.

Late subovata, nitida, rufotestacea, prothorace maculis duabus subeffusis brunneis, elytrorum disco nigro, maculis nonnuelis rugaque subelevatis laete testaceis; caput planum trapezoidale, sublaeve; prothorax ellipticus, lateribus late rotundatis, disco sublaevi; elytra latitudine vix dimidio latiora, angulis humeralibus subacutis, parum prominulis, disco regulariter punctatostriata, basi leviter retusa, subgibbosa; long. 5.5, lat. 4.75 mm.

LUZON, Trinidad (2 specimina in mea collectione a dom. Staudinger).

Breit-eiförmig, subtriangulär, glänzend, rötlichgelb, die Scheibe des Halsschildes mit zwei grossen unscharfen, durch einen schmalen, hellen Streif getrennten Flecken, die Flügeldecken schwarz mit rotgelben Flecken. Schildchen dunkel gerandet; die Brust in der Mitte bräunlich. Kopfschild um ein Viertel länger als breit, trapezförmig, mit glattem, flachem, dreieckigem Mittelfeld und dem Augenrande parallelen Stirnlinien. Die Fühler überragen wenig die Halsschildecken und haben 6 glänzende Basal- und 5 schwach behaarte, matte, verdickte Endglieder; das dritte Glied ist um die Hälfte länger als das zweite und auch merklich länger als das vierte; das fünfte und sechste sind noch etwas kürzer, so lang wie das zweite.

Halsschild elliptisch, um mehr als die Hälfte breiter als lang, an der Seite sehr breit gerundet und wenig kürzer als in der Mitte, mit glänzender, kaum merklich und sehr zerstreut punktulierter Scheibe. Flügeldecken an der Basis um ein Viertel breiter als der Halsschild, mit von diesem seitlich weit abstehenden und mässig vorgezogenen, spitzwinkligen, ziemlich scharfen Schulterecken; hinter diesen sind die Seiten zuerst noch ganz unmerklich erweitert und laufen dann schwach schräg zusammen; die Scheibe hat ziemlich grobe, fast regelmässige Punktstreifen, die auch hinten nicht feiner sind; die Zwischenräume sind kaum breiter; das Basaldreieck ist beider-

[6] Stett. Ent. Zeit. (1916) 349.

seits der Naht schwach eingedrückt, die Profillinie ist an der Höckerstelle, die nicht überhöht ist, winklig gebrochen, hinten anfangs gerade und horizontal. Der letzte Zwischenraum, eine tiefe Einbuchtung an der Seitendachbrücke, eine ebensolche hinten neben der Naht, zwei gemeinsame kleine Flecke, der eine hinter dem Schildchen, der andere hinter der Mitte, sowie je drei grosse, etwas reliefe Flecke hintereinander in der Mitte der Decke sind gelb; von diesen ist der erste rund an der Basis, der zweite gross und unförmlich auf der gegabelten Höcker-Querleiste, aussen ausgerandet, der dritte hinter der Mitte ist aus mehreren zusammengeflossen und bildet mit seinem Gegenüber und der Ausrandung an der Seitendachbrücke einen vor offenen Bogen. Klauen ohne Basalzahn.

Cassida excæcata ist der *luzonica* nahe verwandt, kleiner, schmäler. Die Schulterecken sind mehr zugespitzt und vorgezogen, die Flügeldecken viel mehr nach hinten verengt. Der Kopfschild ist kürzer, das dritte Flügelglied ist länger, die Höckerstelle weniger herausgehoben; die Zwischenräume sind schmäler; endlich ist die Zeichnung verschieden, da der Halsschild dunkle Flecken hat und auf der Scheibe der Flügeldecken nur einige stärker reliefe Flecke gelb bleiben.

THLASPIDOSOMA RIZALENSIS sp. nov.

Rotundata, nitida, glabra, subtus flava, antennis albidoflavis, prothorace elytrisque in discis laete testaceis, parum obscurius signatis, protecto elytrorum ramis duobus brunnescentibus, ceterum ut protectum prothoracis albidohyalino; prothorax longitudine vix duplo latior, angulis subobtusis pone medium; elytra basi emarginata, angulis humeralibus subacutis, basi leviter retusa, tum subgibbosa, subtiliter punctatostriata, punctis apice subeffusis; long. 10, lat. 9.5 mm.

LUZON, Mount Irid (*W. Schultze*).

Annähernd gerundet, mit der grössten Breite wenig vor der Mitte der Flügeldecken, kaum merklich länger als breit, wenig gewölbt, glänzend; unten lebhafter gelb, die Fühler ganz weissgelb, die Scheiben der Flügeldecken und des Halsschildes hell braungelb mit brauner, unscharfer Zeichnung, das Seitendach mit zwei mässig breiten, braunen Randästen, die bis an den Aussenrand reichen, sonst wie das ganze Vordach des Halsschildes glashell, weisslichgelb, durchscheinend. Die braunen Zeichnungen bilden auf der Halsschildscheibe zwei nach vorne konvergierende, kurze Längsbinden; auf den Flügeldecken sind ein kurzer Längsstreif innen von der Schulter und je eine Längsbinde,

braun, die im ersten Längsdrittel hinter dem rückwärtigen Ast der Höcker-Querleiste beginnt, anfangs den 3. und 4. Zwischenraum bedeckt und gegen die Naht konvergiert, wo sie nach dem zweiten Längsdrittel endet. Der vordere Randast des Seitendaches lässt einen glashellen Fleck aussen am Vorderrande frei. Fühler lang und sehr dünn; das 2. Glied kurz, nur doppelt so lang als dick, alle anderen drei bis viermal so lang als das zweite und vier bis fünfmal so lang als dick, unter sich wenig verschieden in der Länge. Kopfschild gut um die Hälfte länger als breit, schwach trapezförmig, mit seichter Mittelrinne und dichter Schagrinierung; die Oberlippe ist oben scharfkantig gerandet, bogenförmig, ober dem Munde weit und seicht ausgerandet, ohne Längskiel. Halsschild fast doppelt so breit als lang, annähernd elliptisch, aber vorne mehr als hinten gerundet, mit abgestumpften Ecken etwas nach der Mitte; Oberseite spiegelglatt. Flügeldecken an der Basis wenig breiter als der Halsschild, ziemlich tief ausgerandet, mit wenig über den Halsschild seitlich vortretenden, schwach vorgezogenen, spitzwinkligen, mässig scharfen Schulterecken; die Scheibe ist wenig gewölbt, sehr undeutlich gehöckert, mit fast geradliniger Profillinie hinter der Höckerstelle; von dieser geht eine flache, breite Querleiste aus, die sich gabelt und zwei schwach herausgewölbte Aeste bis zum 7. Punktstreif sendet, welche die Punktstreifen unterbrechen; auch gegen die Basis geht auf den ersten Zwischenräumen ein höher herausgewölbter, glatterer Ast; die Punktstreifen sind fein, an der Spitze fast erloschen, ihre Zwischenräume mehr als doppelt so breit. Das Seitendach ist fast so breit als eine Decke, glatt, flach ausgebreitet, der äusserste Randsaum schwach aufgebogen.

Die vorstehende Art ist von der zweiten, bisher von den Philippinen Inseln nachgewiesenen *Thlaspidosoma* sehr verschieden. Diese letztere *T. philippina* m.[6] hat auf der sonst gelben Oberseite einen schwarzen, hinten in einen kurzen Zapfen verlängerten Ring, der an der Höckerstelle einen rötlich-gelben Kreis umschliesst. Das Seitendach hat keinen Randast. Zur Zeit der Beschreibung war nur das Männchen bekannt, das sich durch die sehr langen Fühler, welche fast die Körperlänge erreichen, auszeichnet; seitdem liegt mir aus Surigao auf Mindanao auch ein von Baker gesammeltes Weibchen vor, dessen Fühler viel kürzer, nur von halber Körperlänge, sind; insbesonders ist das letzte Glied nur um die Hälfte, beim Männchen aber doppelt so lang als das zehnte.

[6] Stett. Ent. Zeit. 77 (1916) 350.

Die Arten der Gattung Thlaspidosoma.

1 (6). Höcker mässig hoch und spitz; die Profillinie hinter ihm nur seicht ausgerandet.

2 (3). Seitendach ohne Randast; Oberseite mit schwarzem Ring. Mindanao .... *T. philippina* Sp.

3 (2). Seitendach mit Randästen, Oberseite ohne ringförmige Zeichnung.

4 (5). Seitendach mit zwei Randästen .... *T. rizalensis* sp. nov.

5 (4). Seitendach nur hinten mit einem Randast, der wie die Scheiben des Halsschildes und der Flügeldecken pechschwarz ist; der Höcker mit der Querleiste, sowie eine aufgelöste Querbinde hinter der Mitte der Flügeldecken sind gelb (im Leben goldig), das Vor- und Seitendach sowie das Schildchen und ein unscharfer Fleck auf der Basalmakel des Halsschildes hellgelb. 8.5 mal 8 mm. Java .... *T. horsfieldi* Boh.

6 (1). Der Höcker ist hoch, die Profillinie hinter ihm tief ausgerandet.

7 (10). Halsschild vorne weniger gerundet als hinten, so dass die Ecken vor der Mitte liegen.

8 (9). Die Punktstreifen der Flügeldecken haben grobe, dichter hintereinanderstehende Punkte; der Höcker ist niedriger, oben mehr abgestumpft, die Profillinie ist hinter ihm schwächer ausgerandet. Die dunklere Färbung der Oberseite ist nur ein helles Gelbbraun. Die Schulterecken sind weniger scharf.......*T. celebensis* sp. nov.[7]

9 (8). Die Punktstreifen haben sehr seichte, nicht dicht stehende Punkte und sind weniger regelmässig; der Höcker ist hoch, spitzig, die Profillinie ist hinter ihm tief ausgerandet. Die dunkle Zeichnung der Oberseite ist pechschwarz. Schulterecken durch eine Ausrandung der Seiten hinter ihnen scharf. Sumatra, Borneo. Bei der subsp. *limbata* Sp. fehlt der Randast hinter der Mitte des Seitendaches (Borneo) .... *T. dohrni* Sp.

[7] *Thlaspidosoma celebensis* sp. nov. Breit gerundet, hell bräunlichgelb, die Scheiben und eine nicht bis an den Rand reichende, quere Makel hinter der Mitte des Seitendaches hell rötlichbraun; auf den Flügeldecken bleiben ein grosses, gemeinsames Dreieck, das bis über den Höcker reicht, und die Umgebung der Seitendachbrücke, heller. Die Fühler sind bis zum sechsten Gliede gelb (die übrigen Glieder fehlen); das vierte Glied ist doppelt so lang als das zweite und um die Hälfte länger als das dritte. Halsschild fast doppelt so breit als lang, vorne weniger als hinten gerundet, mit abgestumpften Ecken vor der Mitte. Flügeldecken mit vorgezogenen, spitzwinkeligen, aber nicht scharfen Schulterecken, mässig hohem Höcker, beiderseits, vorne tiefer, ausgerandeter Profillinie, groben, tiefen Punktstreifen und kaum breiteren, innen mehr gewölbten und höheren Zwischenräumen, die stellenweise durch kleine Querleisten verbunden sind. Seitendach breit und flach; die Seitendachbrücke geht nach innen nur bis zum achten Streif.

Von der ihr zunächst verwandten *T. dohrni* durch die oben angegebenen Merkmale, mehr elliptischem, vorne mehr gerundetem Halsschild, und der hinter den Schulterecken fehlenden Ausrandung verschieden; 9 mal 9 mm.

CELEBES, Lakini Mont.

Das einzige von den Brüdern Sarasin gesammelte Stück ist im Museum in Basel.

10 (7). Halsschild vorne und hinten gleich gerundet; die mehr abgerundeten Ecken liegen in der Längsmitte.

11(12). Flügeldecken mit einer von einer Seitendachbrücke zur anderen laufenden, nach hinten gerichteten, rötlichgelben Querbinde; der vor dieser Binde gelegene Teil ist dunkel-pechbraun, der dahinter gelegene, ebenso wie der Randast hinter der Mitte des Seitendaches, und die Halsschild-Scheibe, heller holzbraun; 7.25 bis 7 mm; Assam, Mts. Patkoy........................ *T. assamensis* Sp.[8]

12(11). Flügeldecken ohne rötlichgelbe Querbinde.

13(14). Die Scheiben des Halsschildes und der Flügeldecken sind schwarz mit gelben Reliefflecken. Seitendach vorn mit einem abgekürzten, hinten mit einem bis an den Rand reichenden, schwarzen Ast. Das letzte Fühlerglied ist weissgelb, die Basalglieder haben helle Basis; das dritte Glied ist doppelt so lang als das zweite, kaum kürzer als das vierte; 9 mal 8 mm. Kinabalu auf Borneo .... *T. gracilicornis* Sp.[9]

14(13). Scheiben des Halsschildes und der Flügeldecken, sowie ein Randast hinten hellbraun; auf den Flügeldecken sind hellgrüne Reliefflecke. Fühler gelbbraun. Flügeldecken hinten viel breiter abgestutzt 8.5 mal 8 mm. Sumatra.... *T. fallaciosa* Sp.

Genus METRIONA Weise

Ueber *Metriona circumdata* H. habe ich schon geschrieben[10] und zwei ihr nahe verwandte Arten aus Neu-Guinea und von den Molukken abgesondert; die *Metriona trivittata* F. wurde als Rasse der *circumdata* angesprochen; im übrigen habe ich schon damals darauf hingewiesen, dass die Art in eine Reihe von Lokalrassen zerfällt, deren Abgrenzung und Studium reicheres Material mit genauen Fundorten erfordern, als mir damals zur Verfügung stand.

Diese Voraussetzung ist seitdem teilweise erfüllt worden; insbesonders von den Philippinen liegen mir jetzt zahlreiche Stücke vor, die mir ermöglichen einige Lokalformen festzustellen.

METRIONA CIRCUMDATA H. subsp. MINDANAOENSIS subsp. nov.

Männchen sehr kurz und breit, Weibchen viel länger und schmäler. Halsschild vorne und hinten gleichartig gerundet, mit mässig schmal verrundeten Ecken in der Längsmitte; die Flügeldecken sind beim Männchen fast doppelt so breit, kaum länger als breit, mit seitlich vom Halsschild weit abstehenden, wenig scharfen schwach vorgezogenen Schulterecken; beim Weibchen sind die Flügeldecken nur um etwas mehr als die

[8] Vereinssch. d. Ges. Luxemb. Naturfr. (1926) 58.
[9] Stett. Ent. Ztg. 76 (1915) 288.
[10] Ann. Mus. Nat. Hung. 1 (1903) 128.

Hälfte breiter als der Halsschild, um ein Viertel länger als breit; die Schulterecken treten nach aussen weniger vor. Auf dem Halsschild ist vor dem Schildchen ein schmaler, an der Spitze kurz gegabelter Längsstrich; sehr selten setzt er sich vorne nach den Seiten fort und es zeigt sich an der Basis noch beiderseits ein schräger Querstrich, welche Zeichnung ganz klar zu der bei der typischen *circumdata* häufigeren Zeichnung mit zwei birnförmigen, gelben Flecken auf der Basalmakel hinüberleitet. Das Schildchen ist schwarz, oft mit einem gelben Flecke. Auf den Flügeldecken ist eine grosse schwarze Makel, welche an der Basis bis zum vorletzten, selten nur bis zum zweitletzten Punktstreif reicht, an der Seitendachbrücke fast immer tief bis zum sechsten Streif ausgerandet ist (diese Ausrandung fehlt bei einem einzigen Stücke von Nord-Mindanao), sich darauf wieder bis zum vorletzten Streif erweitert und hinten noch zweimal ausgerandet ist; auf jeder Decke sind normal sieben gelbe, kaum erhabene, aber von den Punktreihen nicht durchsetzte, daher glatte Flecke, einer an der Basis, ein grösserer neben der Höckerstelle, zwei dann hintereinander an der Naht, und drei in der Mitte der Decke, davon der mittlere mehr innen, der letzte schräg hinter der Ausrandung; oft fliessen einzelne derselben, besonders jener an der Höckerstelle, mit dem schräg hinter ihm stehenden zusammen, und die bekannte x-förmige Zeichnung wird angedeutet.

Metriona catenata, die eine entfernt ähnliche Zeichnung ist im allgemeinen, kleiner, mehr gewölbt, die Schulterecken springen seitlich weniger vor, die Flecke sind höher relief, die birnförmige Zeichnung des Halsschildes meist vollständig.

Metriona circumdata mindanaoensis ist auf Mindanao sehr häufig; ich kenne sie von Nord-Mindanao (ohne näheren Fundort), Dapitan, Dansalan, Zamboanga, Davao (*Baker, Warburg*); Surigao (*Schultze*), ferner von den Nachbar-Inseln Siargao: Cabuntug, und Samar: Catbalogan; bei diesem letzten Stücke ist der Halsschild einfärbig gelb; 5 mal 4.5 bis 5.5 mal 5 mm.

METRIONA CIRCUMDATA H. subsp. POLILLOENSIS subsp. nov.

Von dieser Form liegen mir nur zwei Stücke vor, die aber ganz übereinstimmen und von verschiedenen Sammlern auf der von Mittel-Luzon östlich gelegenen, kleinen Insel Polillo gesammelt wurden. Diese Form ist sehr gross (6 bis 5.25 mm), der

Halsschild ist vorne weniger als hinten gerundet, so dass die Ecken vor der Mitte liegen, die Flügeldecken haben kaum erweiterte Seiten und stark nach vorne, aber nicht nach aussen vorgezogene Schulterecken; sie sind auch verhältnismässig hoch gewölbt. Der Halsschild ist einfärbig gelb, auf den Flügeldecken sind die Naht bis zur Mitte, an der Höckerstelle breiter, und je eine Aussenbinde schwarz; letztere ist breit, aussen schwach ausgerandet, beginnt auf der Schulterbeule und geht bis hinter die Mitte schräg nach hinten, anfangs vom vorletzten, später vom drittletzten Streif aussen begrenzt.

Das eine der beiden Stücke ist in meiner Sammlung, das zweite in der von Herrn W. Schultze.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XIV [1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

THREE PLATES

The majority of the species described herewith were taken by the Reverend David C. Graham on the border between western China and Tibet, the types being contained in the United States National Museum. A smaller number of Japanese crane flies were captured by Messrs. Esaki and co-workers at the Kiushiu Imperial University, and by Messrs. Imanishi, Machida, Nakamura, Sakaguchi, and Yasumatsu. The material sent by Messrs. Esaki and Yasumatsu is preserved in the entomological collection of the Kiushiu Imperial University; that sent by Messrs. Imanishi, Machida, Nakamura, and Sakaguchi is contained in my collection, through the kindly interest and coöperation of the entomologists in question. I wish to express my deep thanks to all of the above-mentioned gentlemen, and to Dr. John M. Aldrich, of the United States National Museum, through whose intervention I have been able to study the very valuable Graham material.

The crane flies from the China-Tibet border are of unusual interest in that they include certain specimens that were taken at the highest altitude ever reported for these flies; namely, 17,000 feet. The highest previous station was at Phusi-La, Tibet, altitude, 16,500 feet, recorded by Edwards.[2]

TIPULINÆ

TIPULA (SCHUMMELIA) ESAKIANA sp. nov. Plate 1, fig. 1; Plate 2, fig. 23.

Belongs to the *variicornis* group; antennæ (male) elongate, bicolorous; mesonotal præscutum light brown, with three darker brown stripes, the median one further divided by a capillary darker median vitta; fore femora dark brown, remaining femora

[1] Contribution from the entomological laboratory, Massachusetts State College.

[2] Ann. & Mag. Nat. Hist. X 1 (1928) 681–703.

more brownish yellow, with the tips narrowly dark brown; tibiæ and tarsi black; wings with a faint brown tinge, the outer portion of cell R_2 strongly infumed; m-cu connecting with M_{3+4} at about one-third its length; male hypopygium with the median lobe of the tergite relatively small, densely setiferous.

Male.—Length, about 9 millimeters; wing, 8.5; antenna, about 5.

Frontal prolongation of head testaceous-brown; nasus distinct; palpi with basal segments pale brown, the outer segments brownish black. Antennæ (male) elongate, as shown by the measurements; basal three segments yellow; succeeding segments bicolorous, the basal enlargement black, the elongate apical portion light yellow, on outer segments somewhat obscured. Head brown, with a narrow median darker vitta on vertex.

Mesonotal præscutum light brown, with three darker brown stripes, the median one paler at anterior end, divided by a capillary darker median vitta; scutal lobes light brown, each with two darker brown areas; scutellum and mediotergite darker brown, sparsely pruinose. Pleura obscure yellow, variegated with brown on anepisternum, ventral sternopleurite, dorsal pteropleurite, and on pleurotergite. Halteres yellow, the base of knob infuscated. Legs with the coxæ and trochanters yellowish testaceous; fore femora dark brown, paler at bases; middle and hind femora more obscure brownish yellow, the tips narrowly dark brown; tibiæ and tarsi black. Wings (Plate 1, fig. 1) with a faint brownish tinge, the outer three-fourths of cell R_2 strongly infumed; cell C pale brown, cell Sc yellow; very narrow brown seams along veins Cu, m-cu, and anterior cord; whitish areas before and beyond stigma and across cell 1st M_2; veins brown, white in the obliterative areas. Venation: m-cu connecting with M_{3+4} at about one-third its length.

Abdominal tergites obscure brownish yellow, narrowly margined laterally and caudally with blackish; basal sternites more yellowish, the outer ones darkened. Male hypopygium (Plate 2, fig. 23) with the ninth tergite, *9t*, produced medially into a spatulate lobe that is narrower and smaller than in *insulicola*, the entire surface covered with conspicuous erect setulæ, not transversely furrowed and nearly glabrous, as in *insulicola*. Inner dististyle, *id*, with the beak not in alignment with the margin of the blade, but with a slight but distinct emargination at the point of union of the two.

Habitat.—Japan (Kiushiu).

Holotype, male, Sobosan, Bungo, July 13, 1931 (*Esaki and Fujino*).

Tipula (*Schummelia*) *esakiana* is named in honor of my dear friend and colleague, Professor Teiso Esaki, to whom I am particularly indebted for coöperation in making known the rich tipulid fauna of Japan. In its small size and general appearance, it much resembles *T.* (*S.*) *acifera* Alexander (Japan: Shikoku), which, however, has the male hypopygium entirely different in structure, the median lobe of the tergite being nearly cylindrical or slightly narrowed outwardly.

TIPULA (SCHUMMELIA) HONORIFICA sp. nov. Plate 1, fig. 2; Plate 2, fig. 24.

Belongs to the *continuata* group; mesonotal præscutum obscure yellow, with three conspicuous brown stripes that are narrowly bordered by still darker brown, the midline of præscutum thus with a double line of the latter color; antennal flagellum black; head orange, anterior vertex with a capillary black vitta; pleura variegated dark brown and obscure yellow; femora obscure yellow, with a nearly terminal dark brown ring; wings cream-yellow, the costal border brighter yellow, the disk with a heavy dark pattern; Rs about one-half longer than m-cu; male hypopygium with the inner dististyle extended into an acute blackened beak.

Male.—Length, about 13 millimeters; wing, 15.

Frontal prolongation of head orange, brown on sides; nasus lacking; palpi brown, the first segment paler. Antennæ with scape and pedicel yellow; flagellum black; flagellar segments with basal enlargement small, verticils unilaterally arranged. Head deep orange, the anterior vertex with a capillary black median line.

Anterior pronotum brown, narrowly yellow on median line; posterior pronotum broadly sulphur-yellow medially. Mesonotal præscutum obscure yellow, with three, conspicuous, dark brown stripes that are narrowly bordered by still darker brown, the mesal borders of the intermediate stripes forming two delicate parallel vittæ that lie so close as to appear almost single; scutal lobes dark brown, the medial region paler; scutellum and mediotergite brown, obscurely paler on median portion. Pleura chiefly dark brown, variegated by obscure yellow on dorsal anepisternum and sternopleurite; meron chiefly yellow; ventral pleurotergite conspicuously light yellow. Halteres elongate, the stem dirty yellow, the knobs clear light yellow. Legs with the coxæ brownish yellow; trochanters obscure yellow; femora ob-

scure yellow, near tips narrowly dark brown, the extreme tips pale; tibiæ and tarsi black, the extreme bases of former somewhat paler. Wings (Plate 1, fig. 2) with the ground color cream-yellow, cells C and Sc brighter yellow; stigma dark brown; an unusually heavy, paler brown, clouded pattern in most cells, restricting the ground to include most of cell M_1, small areas before and beyond stigma, a small spot at origin of Rs, across fork of M and with areas in cells M, Cu, 1st A, and 2d A; cord, outer medial veins, and vein 2d A narrowly seamed with still darker brown; the brown clouds in cell M with triangular, more grayish centers. Venation: Rs relatively long for this subgenus, about one-half longer than m-cu; R_{1+2} entire, the distal half pale, without trichia.

Abdomen with the basal segments obscure yellow, variegated laterally with brown; segments six to nine black. Male hypopygium (Plate 2, fig. 24) with the caudal margin of tergite, *9t*, deeply notched medially, the lateral lobes broadly rounded; notch relatively narrow, the margin heavily blackened; viewed from the side, the lateral lobes project ventrad into a small acute tooth; viewed from beneath and caudally, the whole outer margin of the tergite on ventral side is produced as an intensely blackened flange, *9t*. Outer dististyle, *od*, long, cylindrical, with conspicuous setæ. Inner dististyle, *id*, small and simple, roughly triangular in outline, extended into an acute blackened spine, the entire cephalic border similarly blackened. Eighth sternite, *8s*, with dense, long, yellow setæ on either side of a narrow, nearly glabrous, median area.

Habitat.—China-Tibet border.

Holotype, male, Yin-Kuan-Tsai, altitude 13,000 to 15,000 feet, July 25, 1930 (*Graham*).

The nearest regional ally of the present fly is the smaller *Tipula* (*Schummelia*) *chumbiensis* Edwards (Tibet), which differs in the short Rs, weakly patterned wings, differently colored femora, and details of structure of the male hypopygium.

TIPULA (ACUTIPULA) INCORRUPTA sp. nov. Plate 2, fig. 25.

General coloration of thorax yellowish gray, the præscutum with four brown stripes; antennæ with basal three segments yellow, the succeeding segments weakly bicolorous, the basal enlargement dark brown, the remainder paler brown, the outer segments more uniformly darkened; wings pale brown, with an oblique whitish band before cord; cells beyond cord not variegated with pale areas; a dark spot in cell Cu before mid-

length; abdomen with basal four segments yellowish, the outer segments blackened; apical lobe of tergite simple, spiculose; eighth sternite unarmed.

Male.—Length, 15 to 16 millimeters; wing, 18 to 19.

Frontal prolongation of head light yellow dorsally, the sides broadly infuscated; nasus conspicuous, yellow; palpi dark brown. Antennæ (male) with the basal three segments yellow, the succeeding segments weakly bicolorous, brown, the basal enlargements dark brown; outer segments more uniformly dark brown; terminal segment reduced to a mere thimble; verticils a little shorter than the segments. Head yellowish gray.

Pronotum obscure yellow medially, darker laterally. Mesonotal præscutum yellowish gray, with four brown stripes, the intermediate pair widely separated; posterior sclerites of mesonotum chiefly yellowish gray. Pleura yellowish gray. Legs with the coxæ yellowish gray; trochanters yellow, femora chiefly brown, the bases restrictedly light yellow, the tips narrowly still darker brown; tibiæ and tarsi rather light brown. Wings with a nearly uniform pale brown tinge; prearcular and costal regions light yellow; an oblique whitish band before cord, extending into base of cell M_3; a less distinct pale spot in outer third of cell M, adjoining vein Cu; cell Cu pale, with a dark spot before midlength; cells beyond cord uniformly darkened; veins brown, paler in the obliterative areas. Venation: Petiole of cell M_1 longer than m.

Abdomen with basal four segments orange-yellow, the tergites narrowly darkened sublaterally; segments five to nine, including hypopygium, black, the outer dististyle of the latter conspicuously whitened. Male hypopygium (Plate 2, fig. 25) with the apical lobe of the ninth tergite, *9t,* simple, spiculose. Inner dististyle, *id,* as shown, the spinulose setæ at apex relatively sparse. Eighth sternite, *8s,* with the caudal margin rounded, not at all produced, the median region with a roughly triangular area of setæ.

Habitat.—China-Tibet border.

Holotype, male, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*). Paratopotypes, 3 males. Paratype, 1 male, Yu-Long-Gong, altitude 14,000 feet, August 14, 1930 (*Graham*).

The present fly rather closely resembles *Tipula* (*Acutipula*) *yunnanica* Edwards in coloration, differing in the details of pattern of antennæ, thoracic notum, and wings, and in the structure of the male hypopygium, notably in the conformation of the

eighth sternite. There are evidently several other allied species of this particular group of flies in the high mountains of central Asia.

The subgenus *Acutipula* Alexander, as modified by Edwards, is represented by numerous species in the eastern Palæarctic region. Among these may be listed from the higher Himalayas, western China, and Tibet, the following species: *Tipula atuntzensis* Edwards, *biramosa* sp. nov., *brunnirostris* Edwards, *cinctoterminalis* Brunetti, *fumicosta* Brunetti, *fumifascipennis* Brunetti, *graphiptera* sp. nov., *incorrupta* sp. nov., *intacta* Alexander, *interrupta* Brunetti, *megaleuca* sp. nov., *munda* Brunetti (*vicaria* Walker, preoccupied), *princeps* Brunetti (including *fuscinervis* Brunetti), *quadrinotata* Brunetti, *robusta* Brunetti, *tenuipes* Brunetti (includes *walkeri* Brunetti, a re-naming of *fulvipennis* Walker, nec De Geer), *subturbida* Alexander, and *yunnanica* Edwards. *Tipula brunnicosta* Brunetti is more doubtfully a member of the subgenus. Additional species from eastern Siberia, Japan, Formosa, and Malaysia, include *bipenicillata* Alexander, *bubo* Alexander, *cockerelliana* Alexander, *de meijerei* Edwards, *kuzuensis* Alexander, *saitamae* Alexander, *shirakii* Edwards, *tokionis* Alexander, and *turbida* Alexander.

TIPULA (ACUTIPULA) GRAPHIPTERA sp. nov.

Allied to *bubo;* general coloration gray, the præscutum with four darker gray stripes that are narrowly bordered by darker; antennæ bicolorous; femora yellow, the tips conspicuously blackened; wings brown, variegated with white, forming longitudinal areas that are narrowly connected across cell 1st M_2; abdominal tergites reddish brown, darker sublaterally and with a capillary median vitta.

Female.—Length, about 25 millimeters; wing, 21 to 22.

Frontal prolongation of head dark reddish brown, the dorsomedian portion and nasus dark brown; palpi black. Antennæ with the scape and pedicel obscure yellow; flagellum obscurely bicolorous, the basal enlargement of each segment black, the remainder brownish yellow, the bicolorous effect persisting to the end of organ; verticils long and conspicuous. Head gray, the posterior vertex with vague indications of a capillary darker line.

Pronotum ocherous. Mesonotal præscutum yellowish gray, with four darker gray stripes that are vaguely and insensibly bordered by brown, most evident along the mesal edge of the

lateral stripe; scutum light gray, each lobe with a darker gray area that is bordered by brown; median line of scutum with a brown area; scutellum and mediotergite gray. Pleura gray, somewhat darker on the anepisternum and ventral sternopleurite; ventral pleurotergite more yellowish; dorsopleural membrane ocherous. Halteres with stem reddish brown, the knobs darker. Legs with the coxæ gray pruinose; trochanters yellow; femora yellow, the tips conspicuously blackened; tibiæ obscure yellow, the tips narrowly dark brown; tarsal segments passing into brown. Wings brown, conspicuously variegated by white areas, forming narrow longitudinal streaks, as follows: Bases of cells Cu, 1st A, and 2d A, the apices of these cells extensively darkened; a square brown spot before midlength of cell Cu; a large whitish area before cord, occupying cell R_1, outer half of R, and at near midlength of M; a narrow outer white stripe includes the narrow bases of cells M_1 to M_4, inclusive, together with the outer half of cell R_5, the two white fasciæ last described being connected across basal half of cell 1st M_2; veins brown, somewhat paler in the white areas; prearcular region brownish yellow.

Abdominal tergites reddish brown, with a very narrow but almost continuous capillary, brown, median vitta, and much broader sublateral stripes that are brown internally and more reddish brown externally; lateral borders of tergites buffy; sternites chiefly yellow. Ovipositor with the cerci long and straight.

Habitat.—China-Tibet border.

Holotype, female, Yu-Long-Si, altitude 15,600 feet, July 23, 1930 (*Graham*). Paratypes, 1 female, Yu-Long-Gong, altitude 14,000 feet, August 14, 1930; 1 female, Tatsienlu, altitude 8,000 to 9,000 feet, August 16, 1930.

Tipula (*Acutipula*) *graphiptera* is most similar to *T.* (*A.*) *bubo* Alexander, differing most evidently in the distribution of the white wing areas, the ones in cells R and M being broadly connected, whereas in *bubo* they are broadly interrupted and separated across the outer ends of cells R and M.

TIPULA (ACUTIPULA) MEGALEUCA sp. nov.

Allied to *bubo;* general coloration gray, the præscutum with four darker gray stripes; antennal flagellum bicolorous; legs yellow; wings brown, with an unusually wide, white, longitudinal stripe extending the entire length; abdominal tergites buffy, with a broad blackish sublateral stripe on either side and a narrow, broken, median brown vitta.

Female.—Length, about 25 millimeters; wing, 23.

Frontal prolongation of head brown, sparsely pruinose; nasus elongate; palpi brownish black. Antennæ with scape and pedicel yellow; flagellum bicolorous, the basal enlargement of each segment brown, the remainder of the segment obscure yellow, on outer segments passing into brownish yellow; verticils much longer than the segments. Head gray.

Mesonotal præscutum light gray, with four darker gray stripes that are relatively ill-delimited against this ground; scutum light gray, the lobes variegated with darker gray; posterior sclerites of mesonotum gray, the caudal portion of mediotergite more yellowish. Pleura chiefly ocherous or yellow, the anepisternum and ventral sternopleurite more grayish; ventral pleurotergite immediately above root of halteres conspicuously infuscated. Halteres with the extreme base of stem and apex of knob pale, the intermediate portion dark brown. Legs with the coxæ and trochanters obscure yellow; remainder of legs pale yellow, only the outer tarsal segments darkened. Wings with the ground color brown, extensively striped longitudinally with white; prearcular region light yellow; the white longitudinal stripe includes the base of cell 2d A, all but the outer ends of cells 1st A and Cu, crosses into cell M at beyond midlength, thence to wing tip, involving the outer third of cell R, much of cell R_1 before stigma, all of 1st M_2, broad bases of cells M_1, 2d M_2, M_3, and M_4, and all but the basal-cephalic portion of cell R_5; a small brown spot before midlength of cell Cu represents the area commonly found in this subgenus; veins brown, paler in the whitish areas. Venation: R_{1+2} persistent; m-cu longer than Rs; M longer than petiole of cell M_1.

Abdominal tergites buffy yellow, with a broad, blackish, sublateral stripe on either side; dorsomedian area of tergite with a very narrow and interrupted median brown vitta, broken on posterior fourth of each segment; lateral borders of tergite broadly and conspicuously pale; basal tergite dark brown; basal sternites chiefly pale, the outer segments more darkened. Ovipositor with the cerci long and straight, slender; hypovalvæ shorter and a little deeper.

Habitat.—China-Tibet border.

Holotype, female, Tatsienlu, altitude 8,000 to 9,000 feet, August 16, 1930 (*Graham*). Paratopotype, female.

Tipula (*Acutipula*) *megaleuca* is quite distinct from all other species that are allied to *bubo* Alexander, in the yellow legs and very conspicuous, uninterrupted, white wing stripe.

TIPULA (ACUTIPULA) BIRAMOSA sp. nov. Plate 1, fig. 3; Plate 2, figs. 26, 27.

Allied to *munda;* mesonotum gray, the pronotum and pleura yellow; wings unmarked except for the stigma and brown costal border; male hypopygium with the inner dististyle produced caudally into two slender spines.

Male.—Length, about 22 to 24 millimeters; wings, 24 to 25.5.

Frontal prolongation of head deep orange; nasus long and slender; palpi dark brown, the incisures of the intermediate segments pale. Antennæ relatively short, slightly shorter than the palpi; basal three segments yellow, succeeding segments bicolorous, the basal enlargement black, the apical portion yellow; terminal segment small, dark-colored, subequal to the basal enlargements of the other segments; verticils very long and conspicuous, as in the group. Head gray.

Pronotum obscure orange-yellow. Mesonotum gray, the præscutum without distinct stripes. Pleura obscure yellow, the dorsopleural membrane more orange. Halteres brown. Legs with the coxæ and trochanters light yellow; femora light brown, the tips dark brown or black; tibiæ and basal three tarsal segments light brown, the tips narrowly and insensibly darkened; terminal tarsal segments black. Wings (Plate 1, fig. 3) grayish subhyaline, the stigma and costal region more infumed, especially the brown cell Sc; central portion of disk in cells M and Cu somewhat clearer, more grayish subhyaline; obliterative areas at cord restricted in area and inconspicuous; veins brown. Venation: Second section of vein M_{1+2} gently arcuated, widening cell 1st M_2; petiole of cell M_1 subequal to or a little shorter than m.

Basal abdominal tergites yellow, with a nearly lateral, brown, longitudinal stripe that widens on the fourth and succeeding segments to cover almost the whole sclerite, the lateral margins pale gray; basal four or five sternites yellow, the outer segments and hypopygium dark brown. Male hypopygium (Plate 2, fig. 26) with the tergite, 9*t,* chiefly fused with the sternite, 9*s;* basistyle fused with sternite, except beneath. Ninth tergite, 9*t,* tumid and dark-colored, with numerous setæ, the caudal margin produced medially into a slender yellow rod that is weakly bifid at apex, each half set with conspicuous black spicules. Outer dististyle (Plate 2, fig. 27, *od*) broadly obtuse, pale, with unusually sparse setæ that are chiefly marginal in distribution. Inner dististyle, *id,* with the caudal margin produced into two slender sclerotized horns. Eighth sternite,

8s, with a rounded median notch, on either side of which is a dense brush of long yellow setæ.

Habitat.—China (Szechwan).

Holotype, male, Fu-Lin, altitude 3,800 to 8,200 feet, 1928 (*Graham*). Paratopotype, male.

The nearest described ally is *Tipula* (*Acutipula*) *munda* Brunetti, which differs conspicuously in the longer, more nearly unicolorous antennæ and in the structure of the male hypopygium, notably of the inner dististyle.

TIPULA (VESTIPLEX) GRAHAMI sp. nov. Plate 1, fig. 4; Plate 2, fig. 28.

Size large (wing, over 20 millimeters); mesonotum gray, the præscutum with four more olive-gray stripes that are narrowly bordered by brown; tips of femora narrowly black; wings brown, variegated by darker brown and cream-colored areas, including a conspicuous postarcular brown area in cells R and M; male hypopygium with the tergite divided medially by pale membrane; basistyle produced dorsally into a powerful black spine.

Male.—Length, about 19 to 20 millimeters; wing, 22 to 23.

Female.—Length, about 27 to 30 millimeters; wing, 23 to 25.

Frontal prolongation of head narrowly yellow above, somewhat darker on sides; palpi dark brown. Antennæ (male) 12-segmented, relatively short, about as long as the palpus; scape and pedicel yellow; basal segment of flagellum brown, the outer segments uniformly darker brown; basal enlargements of segments weak; verticils exceeding the segments; terminal segment small. Front light yellow, posterior sclerites more brownish yellow.

Mesonotal præscutum gray, with four more olive-gray stripes that are narrowly bordered by brown; interspaces more brownish gray; scutum yellowish gray, the lobes with olive-gray areas, the median region with a capillary dark line; scutellum yellow, with a median brown vitta; mediotergite reddish brown, with a capillary brown central line. Pleura grayish yellow, the dorsopleural membrane yellow. Halteres yellow, the knobs dark brown, their apices pale. Legs with the coxæ yellowish gray; trochanters yellow; femora pale brown, the tips narrowly black, the amount about equal on all legs; tibiæ and tarsi brown. Wings (Plate 1, fig. 4) with the ground color brown, variegated by darker brown and cream-colored areas; the darkest area is the stigma; paler brown spots in bases of cells R and M, at origin of Rs, in cell R_1 just before the stigma, and along

anterior cord; the creamy areas include a poststigmal fascia extending from C to cell R_5 but not connecting with the more whitish obliterative streak across cell 1st M_2; other large creamy areas in cell R_1 beyond origin of Rs, subbasally in cells R and M, a large area before outer end of cell M, most of cell Cu and as conspicuous markings at base and near outer end of the anal cells; veins brown. Venation: Petiole of cell M_1 short, less than m, usually about one-half the length; m-cu on M_4 a short distance beyond origin.

Basal four abdominal segments orange-yellow, the tergites narrowly trivittate with dark brown, the lateral areas broadly interrupted; remaining abdominal segments, including hypopygium, black. Male hypopygium (Plate 2, fig. 28) with the suture between tergite, *9t*, and sternite, *9s*, poorly indicated; basistyle entirely cut off by a suture. Ninth tergite, *9t*, completely divided on midline by pale membrane, each half with an outer triangular brown lobe and a conspicuous blackened lobe nearer the midline; mesal region of cephalic portions of tergite densely setiferous. Basistyle, *b*, produced dorsad and slightly caudad into a stout black spine. Outer dististyle, *od*, dusky, clavate in outline, with abundant small setæ. Inner dististyle, *id*, as shown. Eighth sternite, *8s*, with the median region broadly pale and membranous, giving the erroneous impression of being marginate on caudal border.

Habitat.—China-Tibet border.

Holotype, male, Tatsienlu, altitude 8,000 to 9,000 feet, August 16, 1930 (*Graham*). Allotopotype, female. Paratopotypes, 1 female; paratypes, 1 male, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930; 5 females, Yu-Long-Gong, altitude 14,000 feet, August 14, 1930.

Tipula (*Vestiplex*) *grahami* is named in honor of the collector, the Reverend David C. Graham, who has added very materially to our hitherto scanty knowledge of this prolific region. The species is readily told from other regional members of the subgenus by the combination of large size, darkened area near arculus of wings, and the structure of the male hypopygium, as the divided ninth tergite and produced basistyle. The latter feature is found in several other smaller members of the group, as *himalayensis, nigroapicalis, pleuracantha, serricauda, serridens, styligera, subtincta,* and probably others.

The subgenus *Vestiplex* Bezzi, as redefined by Edwards to include the *arctica* and *himalayensis* groups of the genus, is

well-defined in the female sex by the somewhat remarkable ovipositor, with powerful serrulate cerci and greatly reduced hypovalvæ. The group is greatly developed in the eastern Palæarctic region. Among the species known from the higher Himalayas, western China and eastern Tibet, are the following: *avicularia* Edwards, *divisotergata* Alexander, *edentata* Alexander, *grahami* sp. nov., *himalayensis* Brunetti, *inaequidentata* Alexander, *nigroapicalis* Brunetti, *nigrotibialis* Brunetti, *pleuracantha* Edwards, *quasimarmoratipennis* Brunetti, *reposita* Walker (including *brevis* Brunetti), *scandens* Edwards, *styligera* Alexander, *subscripta* Edwards, *subtincta* Brunetti and *tardigrada* Edwards. Additional species from eastern Siberia, eastern China, Japan, and Formosa include *asio* Alexander, *biserra* Edwards, *kuwayamai* Alexander, *nokonis* Alexander, *serricauda* Alexander, *serridens* Alexander, *subapterogyne* Alexander, *subcentralis* Alexander, *teshionis* Alexander, and *verecunda* Alexander. Species with marbled wings that closely simulate members of this subgenus but do not belong to *Vestiplex* include *bodpa* Edwards, *marmoratipennis* Brunetti, *tesselatipennis* Brunetti, *trilobata* Edwards, and members of the *thibetana* group, as *gregoryi* Edwards, *griseipennis* Brunetti, *hobsoni* Edwards, *thibetana* de Meijere, *waltoni* Edwards, and *wardi* Edwards.

TIPULA (LUNATIPULA) TRANSFIXA sp. nov. Plate 1, fig. 5; Plate 2, fig. 29.

General coloration of thorax buffy to gray, the præscutum with four ill-defined brown stripes; antennæ (male) elongate, if bent backward extending to the second abdominal segment, chiefly yellow; femora and tibiæ yellow, the tips narrowly brownish black; wings with a strong yellow tinge, the stigma darker; small cream-colored areas before and beyond stigma, in cell 1st M_2 and in outer end of cell M; abdomen yellow, the subterminal segment more or less darkened; male hypopygium with a pair of pale spatulate blades and another pair of decurved hooks jutting caudad from the notch of the ninth sternite.

Male.—Length, 14 to 17 millimeters; wing, 15 to 17.

Female.—Length, 17 to 22 millimeters; wing, 14 to 17.

Frontal prolongation of head yellowish; nasus long and slender; palpi brownish yellow to brown. Antennæ (male) relatively long, if bent backward extending about to the base of the second abdominal segment; in female shorter, about reaching the wing root; organ chiefly yellow, the basal enlargements of the segments small and darkened: verticils shorter than the seg-

ments (male) or a little longer than segments (female). Head dull gray, more yellowish gray in front.

Mesonotal præscutum buffy, more grayish laterally, with four brown stripes that are relatively ill-defined; scutal lobes gray, variegated with brown; posterior sclerites of mesonotum buffy with vague indications of a capillary brown line. Pleura buffy gray. Halteres yellow, the knobs infuscated. Legs with the coxæ buffy gray; trochanters yellow; femora and tibiæ yellow, the tips narrowly brownish black, somewhat broader on the former; basitarsi brownish yellow, the tips and remainder of tarsi dark brown; tibial spur formula 1–2–2; claws very small, simple. Wings (Plate 1, fig. 5) with a strong yellow to weakly brownish yellow tinge, the costal region more saturated; stigma brown; more cream-yellow areas before and beyond the stigma, across cord in cells M and 1st M_2, and as a small spot in cell M adjoining vein Cu; veins brown. Squama with a few small setæ. Venation: R_{1+2} entire; M_{3+4} about one-half the basal section of M_3; m usually longer than the petiole of cell M_1.

Abdomen yellow, in cases with segment eight (male) slightly darkened. Male hypopygium (Plate 2, fig. 29) of moderate size; tergite, *9t*, and basistyle, *b*, cut off by sutures. Ninth tergite, *9t*, transverse, the caudal margin with a broad U-shaped notch that embraces the whole caudal end of the sclerite, the median portion with a further small notch; caudal margins of tergite blackened and microscopically roughened near midline. Outer dististyle small, narrowly clavate in outline. Inner dististyle *id*, with two blackened apical points, the outer more slender. From the notch of the ninth sternite jut two pairs of appendages, *9s*, consisting of an upper pair of pale spatulate blades and a more ventral pair of decurved hooks; a pendant lobe at caudal-mesal region of ninth sternite. Eighth sternite, *8s*, moderately sheathing, its caudal margin straight, without armature of lobes or enlarged setæ. Ovipositor with smooth, relatively slender valves; hypovalvæ small.

Habitat.—China-Tibet border.

Holotype, male, Yu-Long-Gong, altitude 14,000 feet, August 14, 1930 (*Graham*). Allotype, female, Tatsienlu, altitude 8,000 to 9,000 feet, August 16, 1930. Paratopotypes, 4 of both sexes; paratypes, 9 of both sexes, with allotype; 1 male, Jedo Pass, altitude 12,000 to 15,000 feet, July 17 and 18, 1930; 1 female, Yu-Long-Si, altitude 15,600 feet, July 28, 1930; 1 male, near Tang-Gu, 14,000 feet, August 3 to 6, 1930 (*Graham*).

There are rather numerous, generally similar species of *Lunatipula* in Europe and eastern North America but I know of no regional forms that are at all similar to the present fly. The relatively elongate antennæ, the deeply saturated wings, with restricted paler pattern, and, especially, the structure of the male hypopygium, serve to define the present fly. It may be noted that the peculiar armature jutting from the notch of the ninth sternite, which does not seem to represent any phallosomic development, is often withdrawn into the body so as to be invisible in dry specimens.

TIPULA OREADA sp. nov. Plate 1, fig. 6; Plate 2, fig. 30.

Size large (wing, male, 24 millimeters); general coloration gray, the præscutum with a median brown stripe that is narrowly margined laterally with dark brown; lateral stripes less distinct; wings yellow, the veins narrowly seamed with dark brown, broader along cord; vein R_3 sinuous, slightly narrowing the cell on basal half; male hypopygium with the basistyle produced caudad into a long obtuse point; a single dististyle.

Male.—Length, about 20 millimeters; wing, 24.

Frontal prolongation of head of moderate length, brownish gray; nasus short and stumpy; palpi with basal segment dark brown, the remainder black. Antennæ with the scape and pedicel obscure orange; flagellum brownish black; basal enlargements of segments moderately developed, with long conspicuous verticils that are about equal in length to the segments. Head yellowish gray, the posterior vertex more infuscated laterally.

Pronotum brown laterally, more obscure yellow medially. Mesonotal præscutum light gray, with three stripes, the lateral stripes darker gray and ill-defined; median stripe more brownish gray, clearly defined by narrow dark brown borders that are broader on cephalic half of stripe; posterior sclerites of mesonotum light gray, the scutal lobes marked with vague darker gray areas; posterior portions of scutellum and mediotergite more dusky. Pleura gray, the ventral pleurotergite light yellow. Halteres dusky, the apices of both stem and knob pale. Legs with the coxæ gray; trochanters obscure yellow; femora and tibiæ dark reddish brown, the outer tarsal segments blackened; tibial spur formula 1–?–2, middle legs broken; claws small, with basal spine. Wings (Plate 1, fig. 6) relatively broad; ground color light yellow, the prearcular region deeper yellow; a much restricted dark brown pattern at origin of Rs and along cord; all longitudinal veins similarly seamed very nar-

rowly with dark brown; very pale gray clouds in centers of most cells, restricting the ground to an oblique band at cord, a post-stigmal area in cells R_2 and R_3, bases of cells R and M, outer ends and bases of cells Cu and 1st A, and most of cell 2d A; veins dark. Squama setiferous. Venation: R_{1+2} entire; R_3 sinuous, slightly narrowing cell R_3 before midlength; petiole of cell M_1 shorter than m; m-cu at fork of M_{3+4}.

Basal abdominal tergites obscure yellow, trivittate with dark brown, the lateral stripes more pruinose and interrupted on caudal portions of segments; lateral margins of tergites on outer two-thirds more grayish; outer segments and hypopygium chiefly blackened. Male hypopygium (Plate 2, fig. 30) very large; suture between tergite, *9t*, and sternite, *9s*, complete. Ninth tergite, *9t*, large, the caudal margin with a very conspicuous U-shaped notch, at base of which lie two small triangular points; lateral lobes flattened, their tips obliquely truncated. Basistyle, *b*, cut off by a complete suture, its outer end produced caudad into a long subcylindrical lobe that narrows gradually to the blunt tip, the dorsal surface of this lobe with scattered, long, pale setæ. Dististyle, *d*, single, the outer margin at base with a setiferous lobe which presumably is the homologue of the outer dististyle in those species where this is more evidently cut off from the main body of style. Phallosome, *p*, a small subquadrate mass. Eighth sternite, *8s*, deeply notched medially, with an additional setiferous lobe on either side, together with a dusky liguliform lobe in the notch.

Habitat.—China-Tibet border.

Holotype, male, Yu-Long-Gong, altitude 14,000 feet, August 14, 1930 (*Graham*).

Tipula oreada may perhaps be referred to the subgenus *Nippotipula* Matsumura but differs from the general type of the group in certain regards. The reduced wing pattern and the peculiar male genitalia, especially the long-produced basistyles, should make the species readily distinguishable among the large regional species allied to *pulcherrima* Brunetti and *thibetana* de Meijere.

TIPULA VARIIPETIOLARIS sp. nov. Plate 1, fig. 7; Plate 3, fig. 31.

General coloration gray; præscutum with three darker gray stripes; halteres dark brown; legs reddish brown, the tips of femora and tibiæ narrowly blackened; wings brown, variegated with white including a central streak that extends to the apex in cell R_5; petiole of cell M_1 variable in length, from subequal to

m to quite lacking; male hypopygium with the outer dististyle very small.

Male.—Length, 16 to 17 millimeters; wing, 19.

Frontal prolongation of head stout, gray pruinose; nasus lacking; palpi black, the terminal segment subequal to the second and third taken together. Antennæ (male) of moderate length, if bent backward extending nearly to wing root; scape and pedicel obscure orange; flagellum black; segments with rather conspicuous basal enlargements; verticils subequal to or a little shorter than the segments. Head gray, suffused with brown, the occiput and narrow orbits clearer gray.

Mesonotal præscutum light gray, with three darker gray stripes, the median stripe narrowly margined with brown, the narrow lateral stripes more uniformly darkened; lateral borders of præscutum more or less darkened; posterior sclerites of mesonotum clearer gray, the midline of mediotergite impressed on posterior half. Pleura gray; dorsopleural membrane yellowish brown. Halteres dark brown. Legs relatively stout; coxæ pruinose; trochanters brownish yellow; femora and tibiæ reddish brown, the tips very narrowly blackened, especially of the tibiæ; tarsi black, the proximal ends of basitarsi paler; tibial spur formula 1–2–2, the spurs long and slender, setuliferous; claws small, simple. Wings (Plate 1, fig. 7) with a strong brown suffusion in cells beyond cord, the basal cells paler; prearcular and costal regions more yellowish; a whitish streak runs almost the length of the wing, following vein M to cord, thence through cells 1st M_2 and bases of M_1, 2d M_2, and M_3 to the apex in distal half of R_5; other white streaks along vein M_4, outer third of 1st A, and in basal half of cell 1st A; the pale areas in stigmal region much reduced or lacking, most evident as a weak poststigmal brightening; veins brown. Squama naked; macrotrichia of veins beyond cord short but relatively numerous, lacking on distal thirds of veins R_{1+2} and R_3. Venation: Petiole of cell M_1 very variable in length, from subequal in length to m to quite lacking, in the latter case (including holotype) cell M_1 very deep and entirely sessile.

Basal abdominal tergite gray; tergites two to six orange, broadly blackish gray on sides, the midline very narrowly darkened; sternites and outer tergites, including hypopygium, darkened. Male hypopygium (Plate 3, fig. 31) with the tergite, *9t*, distinct from the sternite, *9s*. Basistyle, *b*, very large, entire, not produced into lobes or spines. Ninth tergite, *9t*, with the caudal margin deeply notched, the median region produced

caudad into a narrow, slightly decurved point; lateral lobes of tergite with mesal flanges to appear as flattened, paddlelike blades; anterolateral portions of tergal plate produced into long arms beneath the eighth tergite. Outer dististyle, *od*, unsually small, only about one-third the length of the inner dististyle, the latter flattened, approximately parallel-sided, the outer margin at base with a small tooth. Eighth sternite, *8s*, deeply notched medially, the sides of notch with several powerful decussate setæ, the outermost a large fasciculate bristle.

Habitat.—China-Tibet border.

Holotype, male, Yin-Kuan-Tsai, altitude 13,000 to 15,000 feet, July 25, 1930 (*Graham*). Paratypes, 2 males, Yu-Long-Gong, altitude 14,000 feet, August 14, 1930; 1 male, Yu-Long-Si, altitude 15,600 feet, July 28, 1930 (*Graham*).

Tipula variipetiolaris has the wings striped longitudinally with whitish, somewhat as in certain members of *Acutipula* or the *tricolor* group, but is very distinct in its structural details, notably of the male hypopygium. No nearly allied species is known to me.

TIPULA SUBMUTILA sp. nov. Plate 1, fig. 8.

Allied to *mutiloides;* general coloration brownish gray, the præscutum with four narrow brown stripes; frontal prolongation of head abruptly light yellow on dorsal surface; nasus distinct; antennæ with basal four segments yellow, the outer segments dark brown; femora yellowish brown, the tips dark brown; ground color of wings brown, with an incomplete pale crossband beyond cord and three more or less confluent pale areas in cells R and M surrounding the origin of Rs; R_{1+2} atrophied.

Female.—Length, about 12 millimeters; wing, 11.

Frontal prolongation of head conspicuously and abruptly light yellow on dorsal portion, the sides dark brown; nasus distinct; palpi dark brown. Antennæ with the basal four segments yellow, the succeeding segments dark brown; verticils about as long as the segment; terminal segment only a little shorter than the twelfth. Head gray laterally, broadly more infuscated on central portion.

Mesonotum obscure brownish gray, the præscutum with four narrow brown stripes, the median interspace more or less suffused; median region of scutum gray, the lobes marked with dark brown; posterior sclerites grayish brown. Pleura gray. Halteres pale, the stem yellow, the base of knob light brown, the apex more whitish. Legs with the fore coxæ gray, the

other coxæ more yellowish; trochanters light yellow; femora yellowish brown, brighter yellow basally, the tips passing to dark brown; tibiæ and basitarsi brown, the outer tarsal segments dark brown; tibial spur formula 1–2–2; claws (female) small, simple. Wings (Plate 1, fig. 8) almost as in *mutiloides;* ground color brown; three nearly equal major whitish areas in cells R and M, in the former cell lying before and beyond the origin of Rs, in the latter cell immediately beneath this origin, these areas more or less confluent and very evident; white crossband beyond cord incomplete, scarcely attaining costa, entering the base of cell M_3; a distinct pale area in outer end of cell 1st A adjoining vein 2d A. Venation: R_{1+2} atrophied; cell 1st M_2 a little longer than in *mutiloides*, cell M_1 shorter and wider.

Abdomen with ground color yellow, the tergites with a median brown stripe; sides of both tergites and sternites weakly pruinose. Ovipositor with the cerci slender, very gently upcurved, the tips subacute; hypovalvæ compressed, narrowed to the pale acute tips.

Habitat.—China-Tibet border.

Holotype, female, Yu-Long-Si, altitude 15,600 feet, August 7, 1930 (*Graham*).

Tipula submutila is most generally similar and allied to *T. mutiloides* Alexander (western China), differing in the diagnostic features above listed, especially the pattern of the præscutum, the pale dorsum of the frontal prolongation of head, yellowish brown femora, and other characters.

TIPULA JEDOENSIS sp. nov. Plate 1, fig. 9.

General coloration gray, the præscutum with four narrow brown stripes, the interspaces with conspicuous black setigerous punctures; antennæ black, the basal two segments yellow; femora with tips blackened, very broadly so on forelegs; wings whitish and brown, with a broad complete white fascia beyond cord; R_{1+2} chiefly atrophied; abdomen yellow, the tergites trivittate with dark brown, the dark areas more extensive on outer segments; ovipositor with cerci long and straight.

Female.—Length, about 14 to 15 millimeters; wing, 13 to 15.

Frontal prolongation of head black, light gray pruinose dorsally; nasus long; palpi black. Antennæ with the scape and pedicel yellow; basal portion of first flagellar segment yellow, the remainder brown; succeeding flagellar segments black; ver-

ticils not exceeding segments; terminal segment about one-third the length of the penultimate. Head brownish gray, the front and anterior orbits clearer gray; a capillary dusky line on vertex.

Mesonotum light gray, the præscutum with four narrow brown stripes, the interspaces, including the midline, with conspicuous brown setigerous punctures; median region of scutum broadly gray, the lobes marked with brown. Pleura light gray, the dorsopleural region more buffy gray. Halteres pale, the knobs dark brown. Legs with the coxæ light gray; trochanters obscure yellow; femora obscure yellow, the tips blackened, more broadly so on the forelegs where about the distal two-thirds are darkened, narrower on the other legs where only the narrow tips are blackened; tibiæ and tarsi black. Wings (Plate 1, fig. 9) with the ground color extensively whitish, variegated by light and dark brown; prearcular and costal regions yellow; a broad complete white crossband beyond cord; similar white bands before cord in outer ends of cells R and M and near wing base in cells R to 2d A, inclusive; stigma brown, confluent with a major dark area on anterior cord; other paler brown areas include the wing tip, a broad band across wing from R to margin in cell 1st A, in cases interrupted in cell Cu; veins brown, yellowish in the pale areas. Squama naked. Venation: R_{1+2} chiefly atrophied, the base more or less persistent as a weak spur without trichia; cell 1st M_2 pentagonal.

Abdomen with basal tergite gray; succeeding segments yellow with a broad, median, brown stripe and somewhat narrower lateral stripes, the dark areas more extensive and more pruinose on outer segments, restricting the ground color to small, obscure, sublateral, yellow portions. Ovipositor with cerci long, slender, and nearly straight, the margins smooth; hypovalvæ shorter and more compressed.

Habitat.—China-Tibet border.

Holotype, female, Jedo Pass, altitude 12,000 to 15,000 feet, July 17 and 18, 1930 (*Graham*). Paratopotype, 1 female; paratype, 1 female, Tatsienlu, altitude 8,000 to 9,000 feet, August 16, 1930.

The only other, approximately similar, regional species is *Tipula submutila* sp. nov., which differs in the pattern of the wings, body, and appendages. The dark setigerous punctures on the præscutal interspaces are very conspicuous and characteristic.

TIPULA MULTISTRIGATA sp. nov. Plate 1, fig. 10.

Mesonotum clear gray, the præscutum with three dark brown stripes, the median one split by a capillary pale line; median area of scutum broadly gray, the dark areas on lobes lying far laterad; wings whitish, variegated with brown, including a complete, narrow, white crossband beyond cord; R_{1+2} atrophied; R_2 very short or nearly lost by approximation of adjoining veins; M_{3+4} about one-third m; intermediate abdominal segments with the lateral margins conspicuously silvery-white.

Female.—Length, about 16 millimeters; wing, 14.

Frontal prolongation of head narrowly brownish yellow above, darker brown on sides; nasus distinct; palpi black. Antennæ with the scape obscure yellow, the basal half darkened; pedicel yellow; flagellum black; verticils exceeding segments. Head gray.

Mesonotal præscutum clear gray, with three, clearly defined, dark brown stripes, the median stripe split by a capillary pale vitta; scutum medially very broadly gray, the usual two dark areas of each scutal lobe lying far laterad; scutellum blackened, damaged in type; mediotergite gray, with a narrow dark brown median line, the posterior portion of sclerite more darkened. Pleura gray, the dorsopleural region buffy. Halteres yellow, the knobs dark brown. Legs with the coxæ gray pruinose; trochanters yellow; femora yellowish brown, the tips dark brown, relatively narrow and subequal in amount of both fore and hind legs (middle legs broken); hind femora with the central portion weakly darkened, leaving the narrow base yellow, with indications of an obscure yellow subterminal ring; tibiæ and basitarsi brownish yellow, the tips narrowly darkened; outer tarsal segments more uniformly blackened, tibial spur formula 1–?–2. Wings (Plate 1, fig. 10) whitish, with a strigate brown pattern that is arranged much as in *tetragramma* Edwards; cells C and Sc clear light yellow; a complete but narrow white crossband beyond cord; outer end of cell R_5 conspicuously white but outer end of cell R_3 uniformly darkened; cells R and M basad of origin of Rs with the dark markings much restricted in area; cell 2d A clear; veins chiefly dark brown. Squama naked. Venation: Tip of R_{1+2} atrophied; R_2 punctiform, so R_1 touches R_{2+3+4} or nearly so; Rs long, slightly exceeding twice m-cu; petiole of cell M_1 exceeding m.

Abdominal segments obscure yellow, trivittate with dark brown, on the fifth and succeeding segments the yellow coloration passing into gray; both tergites and sternites on segments

two to seven, inclusive, with the lateral margins narrowly silvery. Ovipositor with the basal shields shiny black; cerci blackish, reddish basally, relatively straight and slender, the margins smooth.

Habitat.—China-Tibet border.

Holotype, female, Yu-Long-Si, altitude 15,600 feet, August 7, 1930 (*Graham*).

Tipula multistrigata is most nearly allied to the larger and broader-winged *T. latistriga* Edwards (northeast Burma), differing in the pattern of the mesonotum and wings, in the latter with the white crossband beyond cord narrower, the white areas in cells R and M much wider. The venational details of the present form, as the loss of R_2, with cell 1st M_2 narrow and M_{3+4} unusually short, provide additional features for the separation of the two flies.

TIPULA PEDICELLARIS sp. nov. Plate 1, fig. 11; Plate 3, fig. 32.

General coloration gray, the præscutum with a median brown stripe that is trilineate with darker brown; antennæ black, the pedicel abruptly orange; tips of femora broadly blackened, most extensive on forelegs; wings whitish, sparsely patterned with pale brown, the ground color including an incomplete fascia beyond cord; R_{1+2} entire; male hypopygium with the caudal margin of ninth tergite broadly emarginate; eighth sternite with a brush of long yellow setæ.

Male.—Length, about 13 millimeters; wing, 13.2; antenna, 4.

Female.—Length, about 14 millimeters; wing, 12.2; antenna, 2.2.

Frontal prolongation of head yellowish gray above, duller laterally; nasus distinct; palpi black, the terminal segment subequal to or a little shorter than the two preceding segments combined. Antennæ black, the scape pruinose, the pedicel abruptly orange; flagellar segments (male) with weak basal enlargements; verticils shorter than the segments; terminal segment about one-third the length of the penultimate. Head brownish gray, the orbits and vertical tubercle (male) more yellowish gray, the latter weakly notched; in the female the vertical tubercle is not or scarcely developed.

Mesonotal præscutum brownish gray, the lateral stripes narrow to almost obsolete; median stripe conspicuous, the broad margins and narrower median vitta dark brown, the intermediate portions paler brown; stripe narrowed to the suture;

posterior sclerites of mesonotum clearer gray. Pleura gray, the dorsopleural region dusky. Halteres obscure yellow, more brightened at bases, the knobs dark brown. Legs with the coxæ gray pruinose; trochanters reddish yellow; femora reddish yellow basally, the tips broadly blackened, broadest on forelegs where about the basal third is pale, narrowest on posterior femora where about the distal fourth is blackened; tibiæ and basitarsi black, the proximal ends a little paler; remainder of tarsi black; tibial spur formula 1–?–2, the middle legs broken. Wings (Plate 1, fig. 11) with the ground color whitish, with a pale brown clouding over most of disk; cell Sc and prearcular region yellowish, cell C more brownish yellow; stigma darker brown; the ground areas include a narrow incomplete fascia beyond cord, extending from costa to midlength of cell M_3; a broader white fascia, more or less parallel to last-described, lies before stigma, extending across outer ends of cells R and M; cells M, Cu, and basal half of 1st A extensively whitish. Squama naked. Venation: Rs more than one-half longer than m-cu; R_{1+2} long and entire, but pale except for the extreme base, which has two or three trichia; petiole of cell M_1 nearly three times m; m-cu on M_4 just beyond origin; cell 2d A narrow.

Abdominal segments chiefly orange, trivittate with brown, the lateral margins more pruinose; outer segments and hypopygium dark brown. Male hypopygium (Plate 3, fig. 32) relatively large, with the tergite, *9t*, sternite, *9s*, and basistyle, *b*, entirely distinct. Ninth tergite, *9t*, a large thin plate, pale except for the narrowly blackened margin; sclerite broad-based and parallel-sided for more than one-half the length, thence suddenly narrowed; caudal margin very broadly and gently emarginate, with indications of a low and obtuse black median tooth. Outer dististyle, *od*, flattened, pale, expanded outwardly into a spatula. Inner dististyle, *id*, with the heel portion produced into a slender rod that terminates in an acute spine. Ninth sternite, *9s*, with a small fleshy lobule on either side of median line. Eighth sternite, *8s*, sheathing, narrowed outwardly, the median caudal portion further produced into a broad liguliform lobe of thinner texture, this fringed with long yellow setæ.

Habitat.—China-Tibet border.

Holotype, male, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*). Allotype, female, Yin-Kuan-Tsai, altitude 13,000 to 15,000 feet, July 25, 1930 (*Graham*).

Tipula pedicellaris is readily told from the other small regional species by the black antennæ, with only the pedicel

bright orange, the entire vein R_{1+2} and the structure of the male hypopygium.

LIMONIINÆ

LIMONIINI

LIMONIA (DICRANOMYIA) GRAHAMIANA sp. nov. Plate 1, fig. 12; Plate 3, fig. 33.

General coloration of thorax orange, the præscutum with a median brown line; femora yellow, the tips conspicuous dark brown; wings whitish subhyaline, the oval stigma dark brown; male hypopygium with the basistyle and ventral dististyle complicated by outgrowths, the latter with three such prolongations in the rostral region, all but the central one tufted with yellow setæ; ninth tergite with the caudal margin produced medially into a small tridentate plate.

Male.—Length, about 7.5 millimeters; wing, 9.

Rostrum brown; palpi dark brown. Antennæ black throughout; flagellar segments oval, without pedicels; terminal segment one-third longer than penultimate; verticils a little longer than the segments. Head yellowish gray; anterior vertex wider than diameter of scape.

Pronotum dark brown medially, orange-yellow on sides. Mesonotum orange-yellow, the præscutum with a conspicuous brown median line that becomes obsolete far before suture. Pleura orange-yellow. Halteres elongate, pale, the knobs weakly infuscated. Legs with the coxæ orange-yellow; trochanters and femora yellow, the tips of the latter broadly and conspicuously dark brown, the amount subequal on all legs; tibiæ yellow, the extreme bases and tips dark brown, these two areas about equal in degree; basitarsi obscure yellow, the distal third and remainder of tarsi brownish black. Wings (Plate 1, fig. 12) whitish subhyaline; stigma oval, dark brown, conspicuous; veins pale brown. Macrotrichia on veins beyond level of origin of Rs. Venation: Sc_1 ending opposite origin of Rs, Sc_2 some distance from its tip, Sc_1 being about two-thirds the length of Rs; in one wing of type, a weak adventitious crossvein in cell Sc basad of Sc_2; free tip of Sc_2 lying a short distance basad of R_2, the element subequal to R_1 alone; m-cu close to fork of M.

Abdominal tergites dark brown, the caudal margins of the segments very narrowly pale; basal sternites pale yellow, restrictedly darkened at the incisures; outer sternites infuscated; male hypopygium chiefly dark brown, the large outer lobes of the ventral dististyle abruptly white. Male hypopygium (Plate 3, fig. 33) with the median region of tergite, *9t*, produced caudad into a small plate, the apex of which is tridentate. Basistyle,

b, with the ventromesal lobe large and complex, with a small basal and a larger apical brush of setæ. Dorsal dististyle a slender, nearly straight rod. Ventral dististyle, *vd*, large and conspicuous, the sclerotized beak portion deeply trifid, the usual two spines lying in the notch of the outer pair of arms; outer arm long and curved, gradually narrowed outwardly, with a small tuft of yellow setæ; middle arm a smooth adzlike blade; basal arm short and stout, the entire apex with a dense brush of long yellow setæ. Mesal-apical lobe of gonapophysis slender. Ædeagus long and slender, weakly setiferous on basal portion.

Habitat.—China-Tibet border.

Holotype, male, near Tang-Gu, altitute 14,000 feet, August 3 to 6, 1930 (*Graham*).

Limonia (*Dicranomyia*) *grahamiana* is named in honor of the collector of this rich series of Tipulidæ, the Reverend David C. Graham. This fly is very distinct from the now rather numerous species of the subgenus that have the male hypopygium greatly complicated by accessory outgrowths of the basistyle and ventral dististyle (as *stigmatica* Meigen, *magnicauda* Lundström, *complicata* de Meijere of the western Palæarctic region; *bifusifera* Edwards and *megacauda* of the eastern Palæarctic region; *cramptoniana* Alexander, *intricata* Alexander and *platyrostra* Alexander, of the Nearctic region). The nearest regional ally is *bifusifera* from Kashmir, which is very different in the black coloration of the body and legs, and in the details of the male hypopygium.

LIMONIA (DICRANOMYIA) PARAMORIO PLATYSOMA subsp. nov.

Male.—Length, about 5.5 millimeters; wing, 6.5.

Characters as in typical *paramorio* Alexander (eastern China, Yakushima), differing especially in an important feature of the male hypopygium. Each gonapophysis has the mesal-apical lobe very broad, the apex obtuse. In the typical form, the lobe is heavily blackened, slender, curved to the narrow acute point.

Habitat.—Japan (Kyushu).

Holotype, male, Mount Wakasugi, Chikuzen, May 3, 1931 (*Esaki et al.*).

LIMONIA (LIMONIA) EUPHILETA Alexander.

Limonia euphileta ALEXANDER, Insec. Inscit. Menst. 12 (1924) 154.
Limonia biceps ALEXANDER, Ann. & Mag. Nat. Hist. IX 15 (1925) 386–388, figs. 2–3.

The types of *euphileta* were two females from the mountains of Honshiu; the type of *biceps* was a single male from Kyushu.

It now appears from more abundant material taken in Honshiu that the type male was based on a specimen with abnormal venation. Normally, cell 1st M_2 is closed, only in abnormal specimens (but including both wings of the type of *biceps*) being open by the atrophy of m.

LIMONIA (LIMONIA) FUSCICEPS Alexander. Plate 3, fig. 34.

Limonia fusciceps ALEXANDER, Insec. Inscit. Menst. 12 (1924) 155–156.

Described from a unique female taken at Shimokebo, Hitaka, Hokkaido, Japan, August 13, 1923 (*Kuwayama*). One male and two additional females were taken on Mount Shirouma, Shinano, Honshiu, Japan, August 8, 1931 (*Machida and Nakamura*), considerably extending the range southward.

Allotype, male, Mount Shirouma, August 8, 1931. Tips of femora narrowly but conspicuously brownish black. Male hypopygium (Plate 3, fig. 34) with the caudal margin of tergite, 9*t*, very shallowly notched. Dististyle, *d*, dilated and conspicuously hairy on basal half. Gonapophyses, *g*, with the apices blackened, acute, the outer margin back from the tip with an irregularly toothed flange. Apex of ædeagus, *a*, deeply emarginate.

In the present fauna *Limonia* (*Limonia*) *tanakai* Alexander is most similar in its general appearance, having the mesonotum and legs much as in the insect discussed. The ovipositor is quite different in the two flies, being simple in *tanakai*, but with the cerci bifid at the tips in *fusciceps*.

LIMONIA (LIMONIA) PULLATA Alexander. Plate 3, fig. 35.

Limonia pullata ALEXANDER, Insec. Inscit. Menst. 12 (1924) 151–152.

The unique type, a female, was from Hinoëmata, Iwashiro, Honshiu, Japan, July 24, 1923 (*Esaki*). An additional specimen of each sex was taken at Mount Shirouma, Shinano, Honshiu, Japan, August 8, 1931 (*Machida and Nakamura*).

Allotype male, Mount Shirouma, August 8, 1931. Characters as in female, differing as follows: Pedicel of antennæ black, like the scape; basal flagellar segment almost entirely yellow. Femur with the terminal black area slightly more extensive than the yellow subterminal ring; indications of a third dark annulus on each femur just beyond midlength. Eighth and ninth tergites variegated with brown. Male hypopygium (Plate 3, fig. 35) with the caudal margin of tergite, 9*t*, weakly trilobed. Basistyle, *b*, uniformly darkened, the ventromesal lobe occupying the entire face of segment. A single dististyle, *d*, that is suddenly narrowed beyond midlength, passing into yellow and

becoming subangularly bent at this point. Gonapophyses, *g*, with the mesal-apical lobe long and slender, pale.

LIMONIA (LIMONIA) DILUTISSIMA sp. nov. Plate 1, fig. 13; Plate 3, fig. 36.

Belongs to the *flavipes* group; general coloration black, the mesonotal præscutum with the interspaces more reddish; knobs of halteres dark brown; femora obscure yellow, the tips narrowly blackened, preceded by a more or less distinct, more yellowish ring; wings pale yellow, with a diffuse, pale brown, clouded pattern; male hypopygium with the mesal-apical lobe of gonapophysis very short and obtuse at apex.

Male.—Length, 8.5 to 9.5 millimeters; wing, 10 to 11.5.

Female.—Length, 11 to 12 millimeters; wing, 11 to 12.5.

Rostrum and palpi black. Antennæ black throughout; flagellar segments subcylindrical, with the longest verticils more than twice the length of the segments and unilaterally arranged; terminal segment about one-third longer than penultimate. Head black, sparsely pruinose.

Pronótum black. Mesonotal præscutum with the ground color reddish, with heavy black median and sublateral stripes that vary in amount, the sublaterals sometimes much reduced; posterior sclerites of mesonotum chiefly brownish black or black; scutellum usually pale on caudal portion; lateral margins of mediotergite and most of pleurotergite pale. Pleura black, pruinose. Halteres obscure yellow, the knobs dark brown. Legs with the fore coxæ blackened, remaining coxæ obscure yellow, more or less darkened basally; trochanters yellow; femora obscure yellow, the tips narrowly blackened, the amount subequal on all legs, preceded by a more or less distinct clearer yellow ring; tibiæ obscure yellow, the tips narrowly darkened; tarsi chiefly dark brown. Wings (Plate 1, fig. 13) pale yellow, variegated by extensive very pale brown clouds, these including most of cells beyond cord, with other areas in basal portion of wing, as a large cloud in cell R before origin of Rs and others in the outer ends of cells Cu to 2d A, inclusive; vein Cu in cell M seamed with darker brown, especially on basal half, interrupted near outer end by a large cream-colored area; a broad band of the latter color along the cord; veins pale brown, Sc_1 and R_2 so pale as to be nearly obsolete. Venation: Sc_2 ending at near midlength of Rs, much longer than Sc_1; R_{1+2} about three times R_2 alone; m-cu close to fork of M; cell 2d A relatively narrow.

Abdomen, including hypopygium, black, the basal two or three sternites obscure yellow. Male hypopygium (Plate 3, fig. 36)

with the caudal margin of tergite, *9t*, rounded. Basistyle, *b*, with the mesal lobe occupying the entire face and thus not appearing as a lobe. Dististyle, *d*, single, dark-colored except at the narrow base and tip. Gonapophyses, *g*, with the mesal-apical lobe unusually short and obtuse.

Habitat.—China-Tibet border.

Holotype, male, Yin-Kuan-Tsai, altitude 13,000 to 15,000 feet, July 25, 1930 (*Graham*). Allotopotype, female. Paratopotypes, 8 males and females; paratypes, 22 males and females, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930; 6 males and females, Yu-Long-Si, altitude 15,600 feet, July 28 and August 7, 1930.

Among the regional species, this fly seems to be most nearly related to *Limonia* (*Limonia*) *dilutior* Edwards, of the western Palæarctic region. It is well distinguished by the coloration of the body and legs, and by the very obtuse apices of the gonapophyses.

LIMONIA (LIMONIA) HOSTILIS sp. nov. Plate 1, fig. 14.

General coloration dark brown; tips of femora abruptly white; wings with a strong blackish tinge, without whitish areas; Sc_2 elongate, about four times Sc_1.

Sex?—Wing, 11.5 millimeters.

Rostrum and palpi brownish black. Antennæ brownish black throughout; flagellar segments oval, the longest verticils exceeding the segments and unilaterally arranged. Head dark brown.

Pronotum, mesonotum, and pleura almost uniformly dark brown. Halteres dark brown. Legs with the coxæ brown, the fore coxæ more yellowish brown; trochanters obscure yellow; femora dark brown, more brightened basally, the tips narrowly and abruptly whitened; tibiæ and tarsi dark brown; claws with a powerful acute spine on basal half, with a series of smaller serrations lying more basad. Wings (Plate 1, fig. 14) with a strong blackish tinge, the stigma only vaguely indicated and not ringed with a faint line resembling a water-mark; scarcely evident darkened clouds on Sc_2, origin of Rs, and along cord; no pale areas on wing disk; veins brown. Venation: Sc_2 elongate, approximately four times the length of Sc_1; R_2 about one-third R_{1+2}; m-cu at fork of M.

Abdomen broken.

Habitat.—China-Tibet border.

Holotype, 1 specimen, sex unknown, near Yien-Long-Shien, altitude 13,000 to 15,000 feet, August 3 to 6, 1930 (*Graham*).

The only near ally of the present fly would appear to be the larger *Limonia* (*Limonia*) *latipennis* Edwards (northeastern Burma), which is readily told by the size, very broad wings that are conspicuously variegated with whitish areas at cord and beyond stigma, and by the nearly equal veins Sc_1 and Sc_2.

LIMONIA (LIMONIA) KASHMIRICA (Edwards).

Limonia kashmirica EDWARDS, Ann. & Mag. Nat. Hist. IX 20 (1927) 226–227.

Limonia kashmirica EDWARDS, Ann. & Mag. Nat. Hist. X 1 (1928) 701–702.

Described from a female from Kashmir, altitude 11,000 to 13,000 feet. Later recorded from Tibet (Chumbitang, altitude 13,000 feet, July 25, 1924). In the Graham collection from the China-Tibet border were several additional specimens: Yin-Kuan-Tsai, altitude 13,000 to 15,000 feet, July 25, 1930; Yu-Long-Si, altitude 15,600 feet, July 28 and August 7, 1930; near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930.

The present specimens are identical with Edward's Tibetan material, but that the Kashmir type is conspecific with these Tibetan specimens is doubtful. In the present series, all but one individual are considerably larger than the type (female, length, 12 to 14 millimeters; wing, 12 to 14), and they have the anterior vertex narrow as described by Edwards for his Tibetan material, much narrower than in the Kashmir type.

In most of these specimens, there is a distinct, subterminal, black ring on the femora that is usually slightly narrower than the blackened apex but in cases is wider and very distinct, the yellow annulus inclosed being very conspicuous.

LIMONIA (LIMONIA) SYNEMPORA sp. nov. Plate 1, fig. 15.

Belongs to the *flavipes* group, allied to *kashmirica;* general coloration of mesonotum and pleura light reddish brown; wings with the ground color yellow, almost concealed by a slightly darker brown pattern, including areas at origin of Rs, fork of Sc and on R_2; Sc_1 and Sc_2 subequal; m-cu close to fork of M.

Female.—Length, about 14 millimeters; wing, 15.

Rostrum and palpi brownish black. Antennæ dark brown throughout; flagellar segments oval, with relatively short and inconspicuous verticils. Head dark brown, sparsely pruinose; anterior vertex a little wider than diameter of scape.

Pronotum and mesonotum reddish brown, with poorly defined darker markings. Pleura brownish yellow, the pleurotergite

somewhat brighter yellow. Halteres dusky, the base of knob darker, the base of stem and apex of knob yellow. Legs with the fore coxæ brown; remaining coxæ less evidently infuscated; trochanters yellow; femora yellow, the tips narrowly and abruptly brownish black, preceded by a slightly broader, clearer yellow ring that is scarcely delimited on its proximal portion; tibiæ and tarsi light brown, the terminal tarsal segments darker. Wings (Plate 1, fig. 15) with the ground color yellow, almost concealed by a very slightly darker pattern; three small, darker brown areas near costal border, lying at origin of Rs, fork of Sc and on R_2; cord and basal section of M_3 more narrowly bordered with brown; marginal areas of the ground in outer ends of cells 2d M_2 and M_3, and at ends of veins Cu_1, 1st A and 2d A. Venation: Sc_1 and Sc_2 subequal; cell 1st M_2 of moderate size, with m-cu just beyond fork of M.

Abdominal tergites brown, the bases of the segments narrowly obscure yellow; basal sternites obscure yellow, ringed caudally with brown; outer sternites yellow at base, brown laterally and caudally; genital segment obscure yellow.

Habitat.—China-Tibet border.

Holotype, female, Yu-Long-Si, altitude 15,600 feet, July 28, 1930 (*Graham*).

The only near ally of the present fly is *Limonia* (*Limonia*) *kashmirica* (Edwards), which differs especially in the pattern and venation of the wings, notably the elongate Sc_2 and distal position of m-cu.

LIMONIA (LIMONIA) IMPROVISA sp. nov. Plate 1, fig. 16; Plate 3, fig. 37.

Belongs to the *bifasciata* group; mesonotum reddish brown, the præscutum with three more or less distinct brownish black stripes; pleura dark; knobs of halteres darkened; femora yellow with two black subterminal rings; wings yellow, variegated with dark brown; stigmal area solidly darkened; R_{1+2} and R_2 subequal; male hypopygium with the dorsal dististyle a distinct blackened rod; ventral dististyle deeply split into two divergent arms or blades; gonapophyses naked at apices.

Male.—Length, 9 to 10 millimeters; wing, 12 to 13.

Female.—Length, about 10 millimeters; wing, 13.

Rostrum and palpi black. Antennæ brownish black, the pedicel obscure yellow; flagellar segments oval; terminal segment elongate, about equal to the two preceding segments combined. Head dark brown above, obscure orange beneath; anterior vertex narrow.

Mesonotal præscutum reddish brown, brownish black medially and laterally, the ground color in certain cases more restricted than in others by extensions of the dark areas; scutellum obscure yellow behind, darker basally; mediotergite yellow, with a brownish black median line that is wider at cephalic end. Pleura chiefly brownish black. Halteres pale yellow, the knobs abruptly blackened. Legs with the fore coxæ blackened; remaining coxæ and all trochanters yellow; femora yellow, with two conspicuous black rings, one postmedial, the other subterminal, the yellow apex a trifle narrower than the subterminal yellow ring; tibiæ light brown, the tips narrowly darker; tarsi somewhat darker brown. Wings (Plate 1, fig. 16) yellow, variegated with light and dark brown, somewhat as in *quadrinotata* and allies; costal border undarkened except at arculus and fork of Sc; stigma uniformly darkened; a dark area in cell R beyond arculus, with a single additional mark at midway to origin of Rs; paler brown clouds and washes in the apical and caudal cells very conspicuous; veins dark brown. Venation: Sc_1 and Sc_2 subequal; R_{1+2} and R_2 about equal; m-cu before fork of M.

Abdomen obscure yellow, the caudal margins of the segments narrowly and vaguely ringed with brown; hypopygium yellow. Male hypopygium (Plate 3, fig. 37) with the basistyle, *b*, terminating in two fleshy lobes, as in the group. Dorsal dististyle a sinuous blackened spine; ventral dististyle, *vd*, with the two portions deeply divided and widely diverging, the larger and more-flattened rostral portion with setæ. Gonapophyses, *g*, without setæ at tips.

Habitat.—China-Tibet border.

Holotype, male, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*). Allotype, female, Yu-Long-Si, altitude 15,600 feet, August 7, 1930. Paratopotypes, 2 males; paratype, 1 specimen, sex unknown, with allotype.

Limonia (*Limonia*) *improvisa* is most readily told from all described allies by the solidly darkened stigmal area of the wings and by the structure of the hypopygium. The entirely separate dorsal dististyle and the outline of the ventral dististyle remind one of the conditions found in certain *Dicranomyia* species, especially in the *morio* group. In the Nearctic fauna, the fly is closest to *hudsonica* (Osten Sacken); in the Asiatic region it is but distantly allied to species such as *mendax* Alexander, *quadrinotata* (Meigen), and *yunnanica* Edwards.

ANTOCHA (ANTOCHA) FORTIDENS sp. nov. Plate 1, fig. 17; Plate 3, fig. 38.

Male.—Length, about 7.3 millimeters; wing, 8.4.

Very closely allied to *Antocha* (*Antocha*) *nebulipennis* Alexander [3] (western China), differing especially in the structure of the male hypopygium, notably the strong tooth on outer margin of outer dististyle before apex.

General coloration of thorax clear light gray, the præscutum with three conspicuous brown stripes, the median one weakly split on posterior two-thirds by a pale vitta. Knobs of halteres weakly darkened. Legs dark brown. Male hypopygium (Plate 3, fig. 38) with a strong erect spine or tooth on outer margin of outer dististyle, *od*, before the acute tip.

Habitat.—China-Tibet border.

Holotype, male, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*).

PEDICIINI

DICRANOTA (RHAPHIDOLABIS) POLYMERA sp. nov. Plate 1, fig. 18; Plate 3, fig. 39.

General coloration gray, the præscutum with four narrow blackish stripes; antennæ 17-segmented, the scape and pedicel darker than the flagellum; femora yellow, with a conspicuous, nearly terminal, brown ring; wings yellow, the stigma and seams along cord and vein Cu brown; cell R_3 petiolate by presence of vein R_{2+3+4}; male hypopygium with the basistyle divided at apex into two lobes, the outer one slenderer.

Male.—Length, about 6 millimeters; wing, 7.

Rostrum gray; palpi black. Antennæ 17-segmented, relatively short; scape and pedicel black, flagellum pale brown; flagellar segments beyond basal two short-oval. Head gray.

Mesonotum dark gray, the præscutum with four narrow, more blackish stripes, the intermediate pair separated by a line that is more brownish gray than the ground. Pleura dark gray. Halteres pale, the knobs weakly darkened. Legs with the coxæ obscure brownish yellow; trochanters pale yellow; femora yellow, with a broad, dark brown, nearly terminal ring, the extreme apex a trifle paler than the ring itself; tibiæ obscure yellow, the tips narrowly infuscated; tarsi black, the proximal end of basitarsus slightly paler. Wings (Plate 1, fig. 18) relatively narrow, strongly suffused with yellow, the prearcular and costal regions clearer yellow; stigma oval, dark brown; somewhat

[3] Philip. Journ. Sci. 44 (1931) 352–353.

paler brown clouds and seams along entire length of vein Cu_1, the cord, outer medial forks, and the axilla; still paler to scarcely evident clouds at origin of Rs and tip of vein 2d A; veins pale, darker in the infuscated areas. Macrotrichia of veins long and conspicuous. Venation: Sc_1 a distance before origin of Rs about equal to three-fourths the length of the latter; R_{2+3+4} present, shorter than m-cu; R_2 longer than R_{1+2}; R_3 straight; m-cu a little exceeding the second section of M_{3+4}.

Abdominal tergites brownish black; basal sternites a trifle paler, darkened at incisures; hypopygium obscure yellow. Male hypopygium (Plate 3, fig. 39) with the apex of basistyle, *b*, deeply bifid, produced into a slender outer arm that gradually narrows to the subacute tip, the surface with relatively spare setæ, and into an inner arm that is more spatulate, provided with long conspicuous setæ, the outermost longest. A single dististyle, *d*, that is smaller than the inner lobe of basistyle but of about the same shape, densely set with blackened setæ. Interbase, *i*, a long slender blade from a slightly enlarged base. Lateral arm of tergite, 9*t*, only about one-third the size of the interbase but of nearly the same outline. Ædeagus very small.

Habitat.—Japan (Kiushiu).

Holotype, male, Wakasugiyama, Chizuzen, November 15 to 16, 1930 (*Esaki et al.*).

The present fly needs no comparison with any described *Rhaphidolabis*. The presence of 17 antennal segments marks the species as being very distinct, the range in number of antennal segments hitherto known being from 12 to 15, inclusive. The plasticity in the number of antennal segments in several genera, notably in the tribes Hexatomini and Pediciini, is becoming increasingly evident as new material becomes available from all regions of the globe.

DICRANOTA (DICRANOTA) CÆSIA sp. nov. Plate 1, fig. 19.

General coloration light gray, the præscutum with three dark brown stripes; halteres pale, the knobs dusky; legs black; wings whitish, the prearcular region light yellow; membrane with clearly defined brown spots and seams, the latter including a broad seam along vein Cu.

Female.—Length, 8.5 to 9 millimeters; wing, 9.5 to 10.

Rostrum short, gray; palpi black. Antennæ 15-segmented, black; flagellar segments short-oval, with inconspicuous verticils. Head light gray.

Mesonotal præscutum light gray, with three dark brown stripes, the median one broader, entire; lateral stripes less distinct; posterior sclerites of mesonotum dark gray. Pleura light blue-gray. Halteres pale, the knobs dusky. Legs with the coxæ pruinose; trochanters brownish yellow; remainder of legs black. Wings (Plate 1, fig. 19) whitish, the prearcular region light yellow; a conspicuous brown pattern, including spots at Sc_2 and origin of Rs, and seams along cord and vein Cu_1; vein 2d A more narrowly seamed; stigmal area paler brown than the other areas. Venation: Rs arcuated at origin; r-m variable in position, from before the fork of Rs to connecting with R_5 some distance beyond base.

Abdomen gray, the extreme caudal margin of the seventh tergite and intermediate sternites pale. Ovipositor with the cerci rather strongly upcurved, horn-colored.

Habitat.—China-Tibet border.

Holotype, female, near Tang-Gu, altitude 14,000 feet, August 3 to 6, 1930 (*Graham*). Paratopotype, a broken female.

The only allied described species is *Dicranota* (*Dicranota*) *nubecula* Edwards (northeastern Burma); this differs conspicuously in the blackish coloration of the body, which is but slightly if at all pruinose; the uniformly pale halteres; and the diffuse brown areas of the more obscure wings. The broad dark seam along vein Cu_1 is lacking in *nubecula,* while the outer medial forks have large circular brown clouds.

DICRANOTA (DICRANOTA) PALLIDIPES sp. nov. Plate 1, fig. 20.

General coloration gray, the mesonotal præscutum with three brown stripes; knobs of halteres weakly darkened; legs pale, the tips of femora, tibiæ, and basitarsi narrowly and weakly infuscated; wings whitish, with a conspicuous brown pattern that includes a broad seam on vein Cu, this becoming narrower to subobsolete on Cu_1; Rs angulated and spurred at origin; r-m subequal to basal section of R_5; cell 1st M_2 closed.

Sex?—Wing, 10.5 millimeters.

Rostrum gray; palpi black. Antennæ black, broken beyond midlength. Head gray.

Pronotum gray, dark brown medially. Mesonotal præscutum light gray, with three conspicuous dark brown stripes, the broad median vitta weakly notched at extreme cephalic end; posterior sclerites of mesonotum gray. Pleura gray. Halteres pale, the knobs weakly darkened. Legs with the coxæ pruinose; tro-

chanters obscure yellow; femora, tibiæ, and basitarsi obscure yellow, the tips narrowly pale brown; remainder of tarsi passing to darker brown. Wings (Plate 1, fig. 20) with the ground color whitish, conspicuously patterned with dark brown, the arrangement of areas almost exactly as in *cæsia*, the center of the stigmal area paler, more yellowish; a cloud at fork of M_{1+2}. Venation: Rs angulated and short-spurred at origin; R_3 gently arcuated; r-m subequal to basal section of R_5; cell 1st M_2 closed.

Habitat.—China-Tibet border.

Holotype, sex?, Yu-Long-Si, altitude 15,600 feet, August 7, 1930 (*Graham*).

Dicranota (*Dicranota*) *pallidipes* is most nearly related to *D.* (*D.*) *cæsia* sp. nov., differing especially in the coloration of the legs, and in the venation and details of pattern of the wings. These two species, with *D.* (*D.*) *nubecula* Edwards, are the largest and most conspicuous members of the subgenus in eastern Asia.

HETERANGÆUS PALLIDELLUS sp. nov. Plate 1, fig. 21.

General coloration of mesothorax pale yellow; antennæ 13-segmented, flagellum pale yellow; legs yellow, the tips of femora and tibiæ narrowly and abruptly blackened; wings whitish, with a very pale brown pattern, arranged chiefly as broken crossbands; cell C chiefly pale, sparsely variegated by dark spots and dots; Rs weakly angulated, not spurred; supernumerary crossvein in cell R_4 in approximate transverse alignment with R_2.

Female.—Length, 11 to 12 millimeters; wing, 9 to 9.5

Rostrum and palpi brownish black. Antennæ 13-segmented; scape and pedicel dark brown, flagellum light yellow; flagellar segments short, each with one appressed seta that is more than twice the length of the segment alone. Head brownish gray, clearer on the orbits.

Mesonotum and pleura almost uniformly pale yellow, the præscutum with an ill-defined median dark stripe. Halteres pale. Legs yellow, the tips of femora and tibiæ conspicuously blackened; outer tarsal segments blackened. Wings (Plate 1, fig. 21) whitish, with a very pale brown pattern, arranged chiefly as broken crossbands at level of origin of Rs, along cord and across the outer series of supernumerary crossveins; cell C pale, variegated by small brown spots; dark area at origin of Rs only slightly involving cell C; transverse dark areas in cell 1st A lacking or few in number. Venation: Rs weakly

angulated but not spurred at origin; Sc_2 some distance before origin of Rs; supernumerary crossvein in cell R_4 in approximate transverse alignment with R_2; venation of radial field more or less variable, r-m either connecting directly with fork of Rs or up to one-third its length beyond this fork; supernumerary crossvein in cell M_1 at or before midlength of cell.

Abdomen with basal segments yellow, beyond the third passing into dark brown. Ovipositor with the compressed cerci upcurved, blackened basally.

Habitat.—Japan (Honshiu).

Holotype, female, Mount Kurobegoro, Echiu, in subalpine meadow, altitude 7,800 feet, August 8, 1931 (*Imanishi*). Paratopotype, female.

The only other *Heterangæus* with cell C pale, variegated by darker, is *H. gloriosus* (Alexander), of Saghalien. This differs most evidently in the dark wing pattern, with cells C and 1st A more extensively involved, and in the venation, as the long-spurred Rs and the distal position of the supernumerary crossvein in cell R_4.

HETERANGÆUS JAPONICUS CRENATUS subsp. nov.

Male.—Length, about 8 millimeters; wing, 8.

Generally similar to typical *japonicus* (Alexander), differing as follows: Halteres shorter, if bent backward ending shortly beyond midlength of abdominal tergite two; in typical *japonicus* the halteres are unusually long and slender, if bent backward extending to caudal margin of tergite two or nearly so. Wings with the dark pattern broader, restricting the white ground, the dark color deep and more intense. Wings broader, the posterior border strongly crenate, cell 2d A being much wider and more deeply incised than in the typical form.

Habitat.—Japan (Honshiu).

Holotype, male, Mount Ohdai, Nara, June 5, 1930 (*Sakaguchi*).

ULA KIUSHIUENSIS sp. nov. Plate 1, fig. 22; Plate 3, fig. 40.

General coloration of mesonotal præscutum reddish brown, darker medially; postnotum and pleura darker reddish brown; knobs of halteres infuscated; wings with stigmal area almost uniformly darkened, with only a minute paler central area; cell 1st M_2 relatively large, subequal in length to vein M_4; male hypopygium brownish black, the dististyle arcuate, with seven or eight blackened spines that are scattered, some extending down mesal face of style to near midlength.

Male.—Length, about 5.5 millimeters; wing, 6.3.

Rostrum and palpi black. Antennæ black throughout, in male elongate, if bent backward extending to shortly beyond base of abdomen; flagellar segments subcylindrical, with verticils that are shorter than the segments. Head blackish, sparsely pruinose.

Mesonotum reddish brown, the præscutum darker brown medially; postnotum dark reddish brown. Pleura reddish brown. Halteres pale, the knobs dark brown. Legs with the coxæ and trochanters yellow; remainder of legs obscure yellow, the tips of femora, tibiæ, and outer segments of tarsi infuscated. Wings (Plate 1, fig. 22) with a strong brown tinge; stigma almost uniformly darker brown, only the central portion restrictedly paler; a dusky cloud on r-m; scarcely evident smaller clouds on Sc_2 and origin of Rs; veins brown. Venation: Basal section of R_5 eliminated, r-m being at the fork of Rs; cell 1st M_2 subequal in length to vein M_4.

Abdominal tergites uniformly brownish black; sternites obscure yellow, infuscated laterally; hypopygium brownish black. Male hypopygium (Plate 3, fig. 40) with the caudal margin of tergite, *9t*, evenly and convexly rounded, with a marginal series of long setæ. Dististyle, *d*, elongate and slightly arcuate, armed with seven or eight spines that continue down the mesal face of style. What appears to be a lateral tergal arm lies at the lateral portion of the tergite, just mesad of the basistyle and appears as a slender sinuous spine from a dilated base, about the distal half of this spine paling to white.

Habitat.—Japan (Kiushiu).

Holotype, male, Sobosan, Bungo, August 8, 1931 (*K. Yasumatsu*).

Ula kiushiuensis is most generally similar to *U. succincta* Alexander (Honshiu), differing most evidently in the distinct structure of the male hypopygium.

ILLUSTRATIONS

[*a*, Ædeagus; *b*, basistyle; *d*, dististyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternite; *t*, tergite; *vd*, ventral dististyle.]

PLATE 1

PLATE 2

PLATE 3

FIG. 34. *Limonia* (*Limonia*) *fusciceps* Alexander, male hypopygium.
35. *Limonia* (*Limonia*) *pullata* Alexander, male hypopygium.
36. *Limonia* (*Limonia*) *dilutissima* sp. nov., male hypopygium.
37. *Limonia* (*Limonia*) *improvisa* sp. nov., male hypopygium.
38. *Antocha* (*Antocha*) *fortidens* sp. nov., male hypopygium.
39. *Dicranota* (*Rhaphidolabis*) *polymera* sp. nov., male hypopygium.
40. *Ula kiushiuensis* sp. nov., male hypopygium.

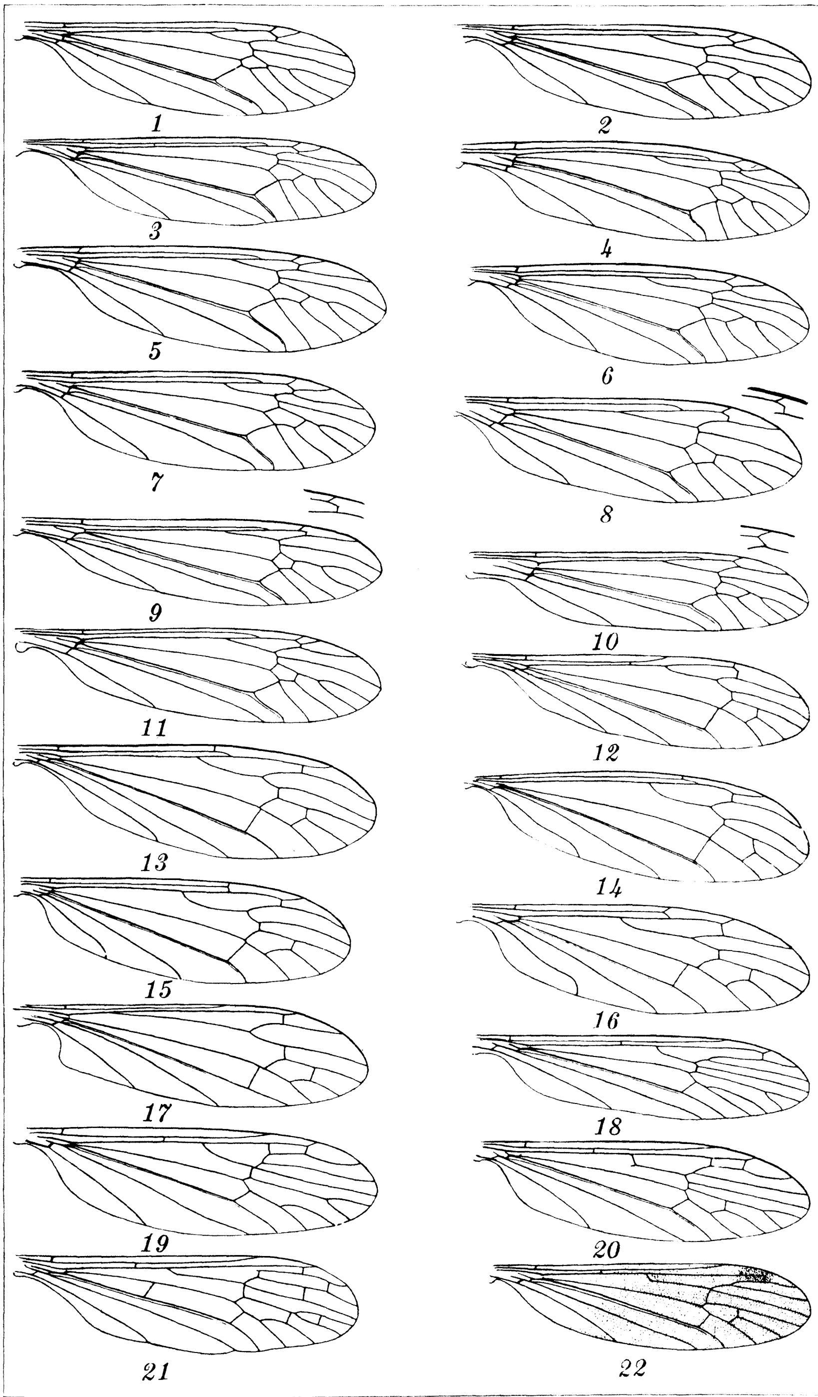
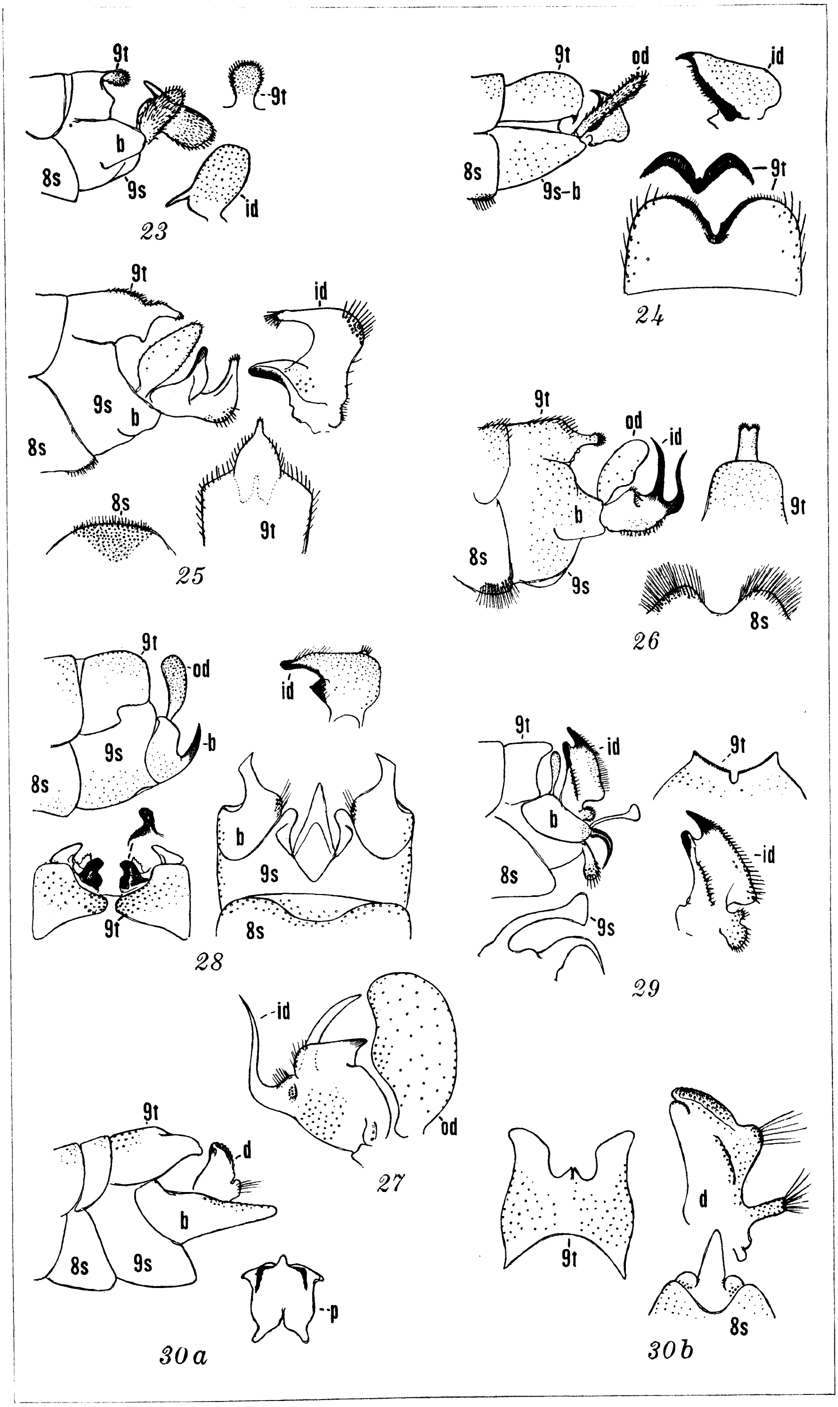


PLATE 1.



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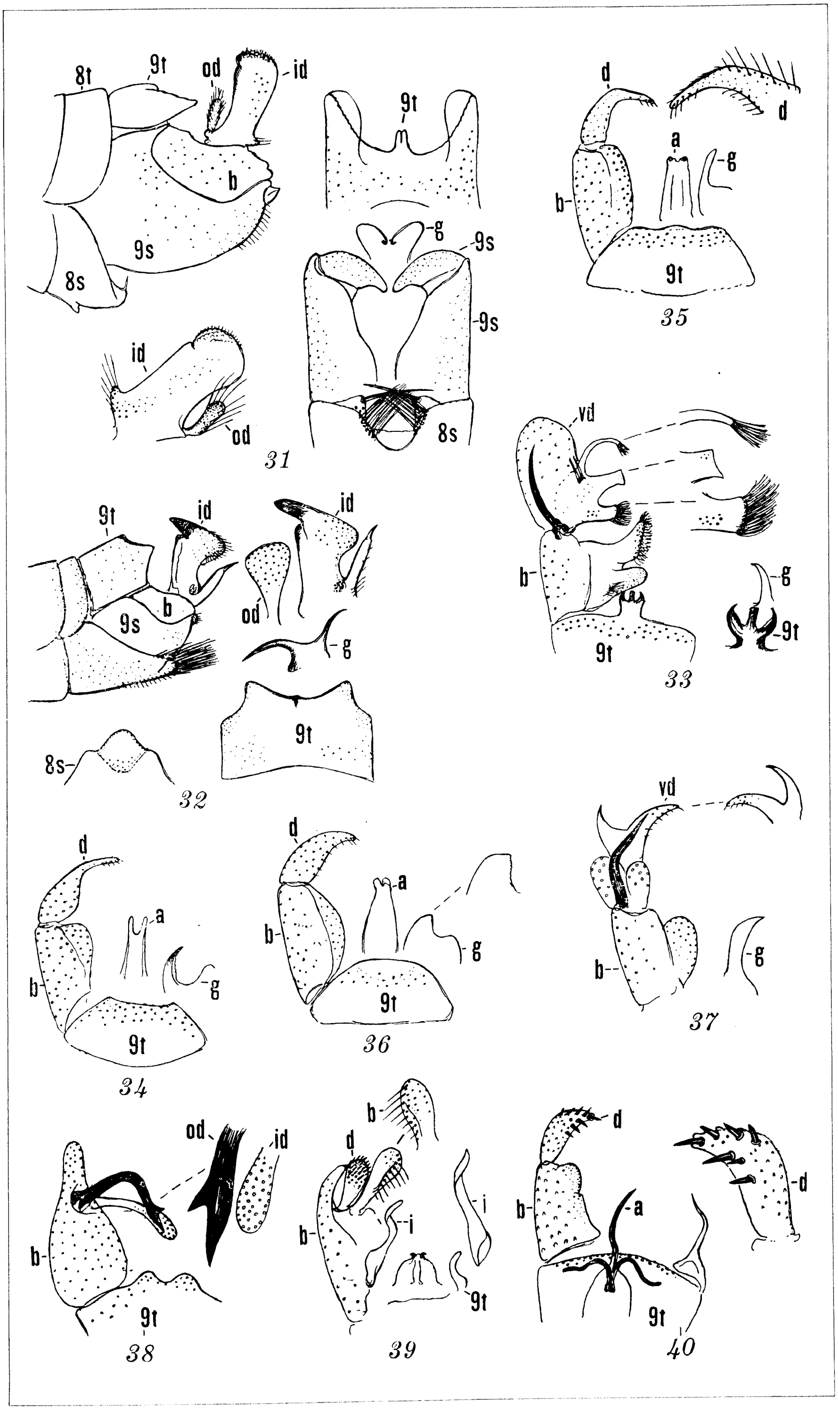
8t
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31
d
a
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i
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PLATE 3.

DESCRIPTIONS OF A NEW GENUS AND ELEVEN NEW SPECIES OF EUPTERYGINÆ (HOMOPTERA) FROM THE PHILIPPINE REGION

By W. L. McAtee

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Most of the specimens upon which this paper is based were sent to me by the late Dr. C. F. Baker and the types are in my collection; the remainder are from the Baker collection now in the United States National Museum. It is suggestive of the wealth of species of the region that nearly every specimen proved distinct on the basis of genital characters. Possibly some species have been described twice on account of present inability to associate the sexes, but settlement of this point must await the accumulation of richer material.

Genus SIROSOMA novum

Venation of both tegmen and wing as in *Erythroneura* but distinct basally in the tegmen; claval vein also evident. The chief distinguishing character is the presence of coarse subcontiguous punctures (relative to the size of the insect they are huge pits) on the clavus, base of corium, pronotum, and head. Those on the body overlie pale pigment spots, and grade into similar maculations apparently not depressed that occur on nearly all parts of the body surface in one species or another.

Type of the genus *Sirosoma hiaticula* sp. nov. here described.

Two previously described groups of Eupteryginæ are said to possess conspicuous punctures. One is *Kybos* Fieber, usually considered a subgenus of *Empoasca* Walsh, but the punctures it possesses are insignificant compared to those characterizing *Sirosoma*. The genus *Aidola* Melichar is described as having the base of clavus and corium with large deep punctures. Nothing is said as to punctures on the head and thorax, and the venation also apparently differs from that of *Sirosoma*, in having only two instead of three sectors of the wing approaching the apical margin.

Key to the species of Sirosoma.

MALES.

a. Outer claspers narrowed subbasally.
b. Inner margins of claspers sinuate near base bounding a prominent elliptical hiatus; lower profile much less than a quarter circle; basal triangles of scutellum and two dots on vertex dark brown; tegmina generally fumose without vittæ.................................*S. hiaticula* sp. nov.
bb. Inner margins of claspers parallel; lower profile of claspers describing nearly a quarter circle, the apices much upturned; basal triangles of scutellum black, a faint narrow dusky vitta traversing the tegmen behind each of these spots; no dots on vertex.
S. arcuata sp. nov.
aa. Outer claspers not narrowed subbasally.
c. Outer claspers conjointly forming a broad flattened sheath, through an opening near the end of which the apices of the inner claspers can be seen; a single bristle on each laterad of this opening; general color fumose, basal triangles of scutellum, a wedge and two dots at middle of vertex, the clypeus, and a vitta each side of face above it dark brown..........................*S. saccula* sp. nov.
cc. Outer claspers otherwise.
d. Outer claspers large, pronotum without black dots.
e. Outer claspers inflated basally, pinched in apically, the apices acute, without median groove; basal triangles of scutellum castaneous, a broad, fumose vitta on each tegmen; no markings on head .... *S. abrupta* sp. nov.
ee. Outer claspers not inflated basally, tapering gradually, the inner margins jointly forming a percurrent longitudinal groove; basal triangles of scutellum black, a narrow fumose vitta behind each on tegmen, two dots on vertex dusky, and median vitta on face black........................ *S. canalicula* sp. nov.
dd. Outer claspers small, pronotum with black dots.
f. Claspers nearly as long as hind tarsus, dark mark at base of corium short .... *S. maquilinga* sp. nov.
ff. Claspers distinctly shorter than hind tarsus, mark at base of corium an elongate vitta............................ *S. bakeri* sp. nov.

FEMALES.

g. Genital plate with a median emargination.
h. Genital plate more than half as long as ovipositor, posterior margin rounded with a slight median emargination; basal triangles of scutellum, two dots on vertex, and two short vittæ below middle of face brown; pronotum brownish, tegmen fumose...... *S. batilla* sp. nov.
hh. Genital plate much less than half as long as ovipositor, with a profound emargination.
i. Emargination U-shaped; scutellum pale, two black dots on pronotum near hind margin, and a black dash on base of corium.
S. maquilinga sp. nov.

ii. Emargination V-shaped; basal triangles of scutellum black; disk of pronotum and of face brown, and faint broad vitta on tegmen dusky.
S. emarginata sp. nov.

gg. Genital plate with a median projection, each side of which is rounded emarginate.

j. Median part of hind margin of genital plate broadly rounded; basal triangles of scutellum and oval spot on lower part of face black; tegmina white.
S. frontalis sp. nov.

jj. Median part of hind margin of genital plate in the form of a short produced, thickened, almost knob-like, process; no spots on scutellum or head; tegmina greenish yellow on inner half.
S. clavata sp. nov.

SIROSOMA HIATICULA sp. nov.

General color above yellowish fumose; basal triangles of scutellum, and a roundish dot each side of and near middle of vertex, dark brown; face pale brownish except peripherally; pleura and dorsum of abdomen dark brown (nearly black); venter pale brownish.

Vertex rounded, rather short, but little longer at middle than along eye; coarse punctures restricted to basal half of clavus and corium, rather evenly distributed over scutellum (except basal triangles), pronotum, and pleura, except that there is a smooth area between front and mid coxæ; on the head there is an oval group on middle of face connected upwardly with a dense group covering upper part of face and the vertex, from which a tract extends also over the disk of each cheek; abdomen pale dotted both above and below. Outer claspers as described in key. Length 3.5 millimeters.

Holotype male, Sandakan, Borneo.

SIROSOMA ARCUATA sp. nov.

General color of head and thorax above pale ivory, a semicircular mark connected with the black basal triangles of scutellum showing duskily through the pronotum; tegmen whitish hyaline with a narrow dusky percurrent vitta paralleling inner margin; underparts stramineous, somewhat sordid on face.

Vertex moderately long, rounded, but little longer at middle than along eye; coarse punctures restricted to basal half of clavus and corium; generally prevalent on scutellum (except basal triangles), and on pronotum except near hind margin; a row near hind margin of vertex, large groups on the disk of face, and each cheek, the head otherwise smooth; pleura and dorsum

pale dotted, venter only obscurely so if at all. Outer claspers as described in key. Length 4 millimeters.

Holotype male, Mount Maquiling, Luzon.

SIROSOMA SACCULA sp. nov.

Vertex ivory with a median black wedge from hind margin projecting between two ovoid black spots; pronotum mostly livid, anterior margin ivory; scutellum livid, the basal triangles brown; tegmina fumose; face ivory, clypeus and a triangular marking above it each side of front; abdomen slaty both above and below; legs and genitalia stramineous.

Vertex rounded, rather short, about one-third longer at middle than next to eye; coarse punctures restricted to basal half of clavus and basal fourth of corium; scutellum coarse-punctate except for apex and basal triangles; pronotum generally coarse-punctate; punctures conspicuous on cheeks, sparse but discernible elsewhere on head; pleura, and abdomen both above and below, pale dotted. Outer claspers as described in key. Length 3.5 millimeters.

Holotype male, Sandakan, Borneo (United States National Museum).

SIROSOMA ABRUPTA sp. nov.

General color of head and thorax above yellowish fumose, basal triangles of scutellum castaneous; tegmen whitish hyaline with a broad, median percurrent, fumose, longitudinal vitta; lower parts stramineous, most of face with a pale yellowish brown wash.

Vertex rounded, moderately long, about one and one-half times as long at middle as along inner margin of eye; coarse punctures restricted to basal half of scutellum and basal fourth of corium; generally distributed on scutellum except basal triangles, and on pronotum except for a rather broad posterior edging moderately expanded anteriorly on each side of middle; those on head distributed as in the last species, *S. arcuata*, but more sparsely; punctures evident on pleura; abdomen with pale pigment dots both above and below. Outer claspers as described in key. Length 3.5 millimeters.

Holotype male, Sandakan, Borneo.

SIROSOMA CANALICULA sp. nov.

General color of head and thorax above pale yellowish, a dusky triangular marking connected with the black basal triangles of scutellum showing through pronotum; a dark brown elliptical dot on each side about midway between middle of vertex and

eye; underparts somewhat sordid stramineous, face with a broad median blackish brown vitta, narrowed above; dorsum of abdomen dark brown.

Vertex rounded, rather short, only a little longer at middle than along inner margin of eyes; coarse punctures restricted to basal fourth of corium, but occurring over nearly all of clavus; dotting scutellum except basal triangles; disk and broad hind margin of pronotum polished, the punctures on anterior portion exceptionally large; head with sparse coarse punctures on vertex, middle of face, and disk of cheeks, otherwise polished; pleura punctate, abdomen pale dotted above. Outer claspers as described in key. Length 5 millimeters.

Holotype male, Los Baños, Luzon.

SIROSOMA MAQUILINGA sp. nov.

Color above stramineous washed with greenish yellow anteriorly; pronotum with large black spot near hind margin on each side in front of anterior angle of scutellum; tegmen with a short black dash in middle of corium near base; extreme apex of scutellum and disk of tergum black in male; lower parts stramineous; breast and apices of claspers black in male; ovipositor of female brown.

Vertex rounded, short, nearly the same length at all points; coarse punctures visible on basal half of clavus and basal fifth of tegmen; conspicuous on scutellum except basal triangles and apex which are polished; punctures very coarse and generally distributed on pronotum except along hind margin; head polished so that punctures are obsolete except on cheeks; pleura punctate, and pale dots visible on dark tergum of male; not evident on pale portions of abdomen; genitalia as described in key. Length 3 to 3.5 millimeters.

Holotype male and allotype female, Mount Maquiling, Luzon (United States National Museum).

SIROSOMA BAKERI sp. nov.

Head and thorax above stramineous, tegmina whitish hyaline; pronotum with two black dots posteriorly as in *maquilinga;* a tiny dash on edge of scutellum behind each of them; dusky vitta on corium about two-thirds as long as clavus, dense basally, evanescent distally; lower parts stramineous.

Vertex short, rounded, of about equal length at all points; distribution of coarse punctures as in *maquilinga.* Length 3.25 millimeters.

Holotype male, Mount Maquiling, Luzon (United States National Museum).

SIROSOMA BATILLA sp. nov.

General color of head and thorax above fulvous, pronotum with some brown flecks anterolaterally, and with a dark horseshoe-shaped marking connecting posteriorly with the black scutellar triangles dimly showing through; vertex with a pair of large roundish polished black spots near together at middle; tegmina fumose; face varying from stramineous on cheeks to ivory at middle and fulvous near vertex, with a short dark brown vitta each side of middle above clypeus; legs and genital plate stramineous; abdomen dark brown both above and below.

Vertex rounded, moderately long, of about same length at all points; coarse punctures chiefly restricted to basal half of clavus and to basal fourth of corium; they or the pigment dots about evenly distributed over scutellum except apex and basal triangles, pronotum, vertex, and face, pleura, and abdomen both above and below; a few are present even on the ovipositor sheath; genital plate like an inverted scoop, stramineous, with a brownish lunate depression near base, otherwise as described in key. Length 3.5 millimeters.

Holotype female, Singapore.

SIROSOMA EMARGINATA sp. nov.

General color of head and thorax above stramineous, vertex with a faint dusky point each side near middle; pronotum except broad anterior margin underlaid by fuscous; scutellar triangles black, disk fumose; clavi within claval veins greenish white, tegmen fumose with broad costal margin and a longitudinal streak just exterior to apex of clavus, hyaline; face stramineous, disk brownish; legs stramineous, abdomen dark brown both above and below.

Vertex rounded, about one and one-half times longer at middle than next to eye; coarse punctures mostly restricted to basal half of clavus, and basal fourth of corium, and disk of scutellum; pronotum generally coarse punctate except along hind margin; head coarse punctate except for apex, clypeus, and lateral margins of cheeks; pleura coarse punctate and abdomen pale dotted both above and below; genital plate as described in key. Length 4 millimeters.

Holotype female, Sandakan, Borneo.

SIROSOMA FRONTALIS sp. nov.

General color of head and thorax above stramineous, a pair of faint brownish dots on vertex near middle; small basal triangles of scutellum black; tegmina whitish hyaline; face stramineous with a median oval, dark brown spot just above clypeus; legs, venter, and connexivum stramineous; disk of dorsal surface of abdomen brownish.

Vertex rounded, rather short, of about same length throughout; coarse punctures distributed over whole clavus, and basal half of corium, disk of scutellum, all of pronotum except narrow hind margin; cheeks densely coarse punctate, a few punctures along each side of middle of face, and along hind margin of vertex, head otherwise nearly smooth; abdomen without pale dots; genital plate as described in key. Length 4 millimeters.

Holotype female, Basilan Island.

SIROSOMA CLAVATA sp. nov.

Head and thorax above uniform honey-colored; tegmina whitish hyaline with a brassy wash over clavus and adjacent corium, somewhat fumose apically; underparts honey-colored, legs paler, disk of dorsum of abdomen brownish.

Vertex rounded, moderately long, about one and one-half times as long at middle as along eye; coarse punctures restricted to basal half of clavus, basal fifth of corium, and disk of scutellum; pronotum coarse punctate except for broad hind margin; coarse punctures (or their analogues) present over most of head (except rondure from vertex to face) but difficult to see; pleura punctate; pigment dots visible on dark, but not on other, portions of abdomen. Genital plate as described in key. Length 4 millimeters.

Holotype female, Sandakan, Borneo.

TERMINOLOGY USED FOR ANOPHELES OF THE FUNESTUS-MINIMUS SUBGROUP IN RECENT PAPERS BY RUSSELL AND OTHERS

By PAUL F. RUSSELL

Member of Field Staff of the International Health Division the Rockefeller Foundation

King(1) has recently published a detailed study of the *funestus-minimus* subgroup of *Anopheles* which he now considers to include in the Philippines three species; namely, *A. minimus* var. *flavirostris* Ludlow 1914, *A. mangyanus* Banks 1907, and *A. filipinae* Manalang 1930. This new arrangement of the very important *funestus-minimus* subgroup appears to meet the situation better than any previous study and is likely to become the accepted classification. Therefore, it seems advisable to write these notes based on a reconsideration of specimens reported by the author and his colleagues in some publications which were in manuscript prior to King's final conclusions.

In the first report by Russell(2) on daytime resting places of adult anophelines, "*Anopheles minimus* (Theobald 1901)" of Tables 3 and 4, page 646, includes both *Anopheles minimus* var. *flavirostris* Ludlow and *Anopheles mangyanus* Banks as described by King.(1) In the second report by Russell(3) "*A. minimus*" referred to throughout the report is *A. minimus* var. *flavirostris* of King.(1)

In a paper by Russell(4) regarding larva control by stranding and flushing, "*A. minimus*" includes the *funestus-minimus* subgroup of King.(1) In a paper by Russell and Santiago(5) the *A. minimus* larvæ referred to as having been found in wells were *A. minimus* var. *flavirostris* of King.(1)

Finally, in a paper by Holt and Russell,(6) reporting malaria and *Anopheles* reconnaissance, wherever the term "*minimus* group" has been used King's(1) term of "*funestus-minimus* subgroup" may be substituted. Wherever the name "*A. minimus*" is used, *A. minimus* var. *flavirostris* may be understood.

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THE CAST NET AS A DEEP-WATER FISHING APPLIANCE IN MANILA BAY *

By Agustin F. Umali
Of the Fish and Game Administration, Manila

THREE PLATES AND SIX TEXT FIGURES

INTRODUCTION

The cast net, locally known as *dala* in Tagalog, *laya* in Visayan and Bicol, *tabocol* in Ilocano, *sabucol* in Pangasinan, *lala* in Zambal, and *atarraya* in Tao Sug and Samal, is perhaps the oldest type of fishing net known to man. It is especially interesting in that the hand net used by the apostles during Biblical times as mentioned in the New Testament is said to be one similar to the present-day cast net. It is a net which has been universally in use since time immemorial.

In the Philippines, this net is the kind generally used by both the Christian and the Mohammedan Filipinos. Its commonest use, of which much has been written, is along estuaries, banks of rivers and lakes, and wading depths on sea beaches where an individual fisherman with a net and a basket for the catch plies his trade on a small scale. A fisherman stealthily wading in a stooping position, spying the presence of fish and ever ready to cast his net over his unsuspecting victims, is a common sight near fishing villages.

Less frequently observed is the use of the dala in deep water. Here its extensive utilization has necessitated an increase in its size and the employment of a boat in connection with its operation. The use of this net in deeper waters, especially popular among the native fishermen of Rizal and Bataan where fleets of such outfits are seasonally observed, is the subject of the present discussion.

THE FISHING GROUND

The sphere of operation of this fleet of dala fishermen from Rizal and Bataan is the open waters of Manila Bay, where there

* Contribution No. 1 from the Fish and Game Administration, Department of Agriculture and Commerce.

are vast schools of herrings and other pelagic species. As the boats used are small, they seldom venture into the open sea. Any bay or gulf, which is the natural abode of pelagic species that move in shoals, is a favorable fishing ground for the operation of this gear.

THE BOATS

The boats employed are ordinary dugouts or bancas of the outrigger type with an average capacity of about one-half ton net (Plate 1, fig. 1). They are about 30 feet in length with a width of 3 feet and a depth of 2 feet. Each boat is rowed by from three to four oarsmen, and when the wind is favorable, a sail is hoisted to the top of a detachable mast.

In the prow of the boat is a somewhat elevated, rectangular, wooden platform about 3 feet long and about 2 feet wide (Plate 1, fig. 2). This serves as a stage for the dala thrower when he casts the net. Behind the forward crosspiece of the outrigger is a bamboo pole about 5 feet high, which is provided with a curved end that forms a hook from which the net with the gilled fish is hung for the convenience of the fishermen in removing the catch from its meshes. A support is provided for the detachable wooden mast where the latter is stepped well forward at a point just aft of the platform.

The anterior third of the hold of the boat behind the platform, which is provided with some sort of flooring, serves as the working place for the mending of the nets, the picking and sorting of the catch, and the storing of the reserve nets and the catch. The central portion of the boat is for the rowers, each of them being provided with one oar and a paddle—the former is used when reconnoitering for schools of fish, and the latter is employed when approaching the school with caution and perfect quiet in order not to frighten the fish into diving.

In the stern is the place of the steersman, who is provided with a special paddle, as the boat has no rudder. Behind the place of the steersman is another bamboo pole of almost the same size and length as the one in the bow which, is conjunction with the latter, serves to make secure the awning spread as a protection against the sun.

THE FISHERMEN

A dala fishing outfit of this type is manned by from five to seven fishermen. One of them is an expert in the art of casting the net and at the same time skilled in the differentiation of schools of fish by the disturbance created on the surface of

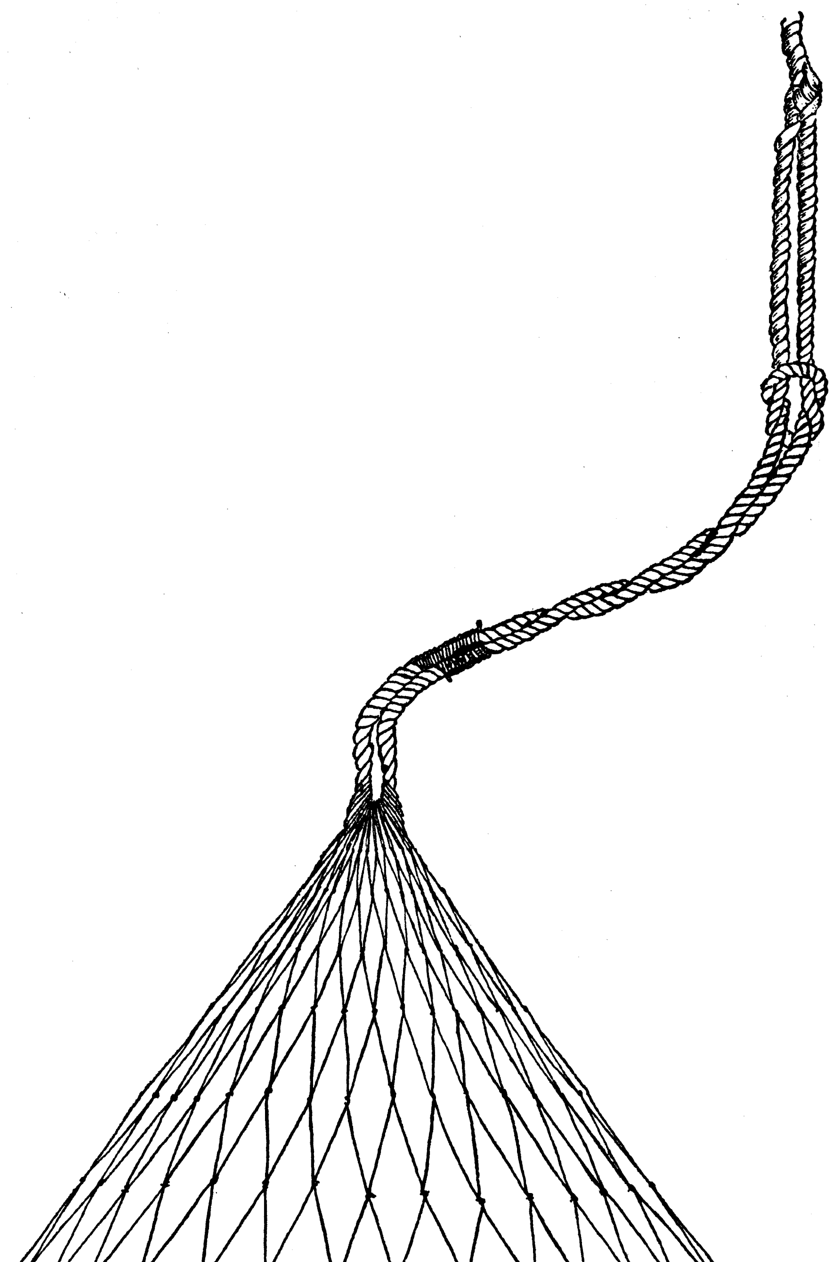

FIG. 1. The apical portion of a typical dala, showing attachment of hauling-in line.

the water as they swim about. Another member of the crew is the steersman, whose main work is to direct the course of the vessel according to instructions from the expert thrower. The rest are the oarsmen, who row the boat and also help in picking the gilled fish from the meshes of the net.

THE FISHING GEAR

The dala is a circular net, heavily weighted with lead sinkers around its lower edge and provided with a hauling-in line attached to the apical portion. When distended, it has the form of a cone; when thrown into the water, it settles like an open

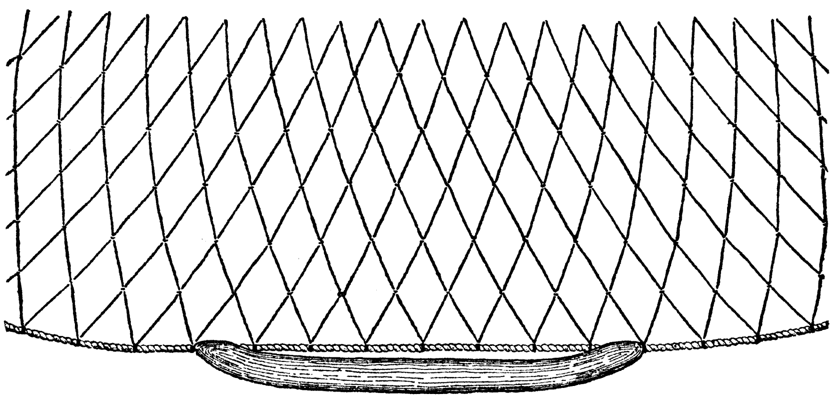

FIG. 2. Portion of weighted edge of the dala, showing the way the lead sinkers are attached.

umbrella, and when it is drawn out by pulling on the main cord, the sinkers gather together giving the net the appearance of a closed or collapsed umbrella.

The cast net has two main parts; namely, the hauling-in line and the net proper. The line, which varies in length from 40 to 60 feet, is a $\frac{1}{4}$-inch[1] cotton string. In the typical dala, (text fig. 1), it is directly attached to the apical line that supports the webbing of the apex of the supposedly conelike net. It acts as a retrieving line in the actual casting operation. The greater portion of its length is coiled on the elevated platform when the net is still uncast.

The net itself is the main portion of the gear that either impounds or more generally gills the fishes. It is about 30 feet high with a diameter of about 25 feet at the base. The meshes of the web and the size and kind of the twine used are dependent upon the size and kind of fish for which the net is espe-

[1] The measurements of the lines in this work are the diameters.

cially constructed. The netting of the upper two-thirds of the majority of the dala observed is of No. 50 linen thread and the lower one-third of No. 40. As mentioned in a foregoing paragraph, the lower edge is heavily weighted with lead sinkers strung at regular intervals (text fig. 2). These weights, which are cylindrical, are about 4¼ inches long and about ¼ inch in diameter; each sinker weighs about 1½ ounces and is provided with two perforated projections that serve to hold it to the edge of the net.

Of a rather different make is the *pangduhay*, the dala used for catching pomfrets (*duhay*) *Stromateus niger* (Bloch). In addition to the net proper, in this case of China-grass [*Boehmeria nivea* (Linn.) Gaudich.] twine, there are about twenty baited lines (text fig. 3), each of ⅜-inch cotton rope about 25 feet long, provided with a wooden float at one end while to the opposite end, which is weighted with a stone, are attached several jellyfishes that serve as the bait. These accessory parts are used to attract the pomfrets upon which the net is cast. Another accessory implement is the *pamangkao*, a long-handled scoop (text fig. 4), which is used for scooping and raising the baited lines from the water when determining whether or not the pomfrets have been attracted. The handle is a bamboo pole about 15 feet long, while the scoop proper is a netting of No. 20 cotton twine webbed with a mesh of 1 inch stretched that is

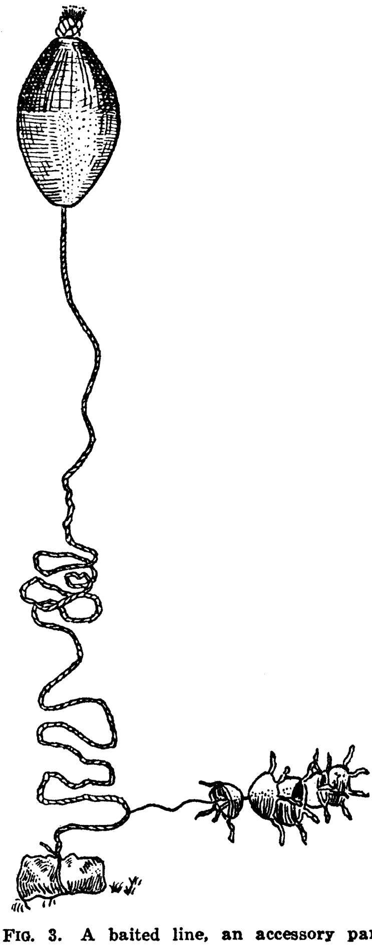

FIG. 3. A baited line, an accessory part of a panduhay.

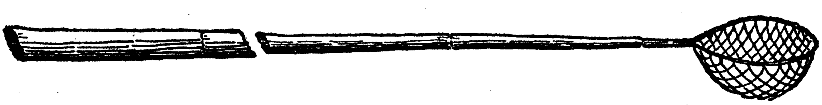

FIG. 4. The pamangkao, a long-handled scoop.

laced to an iron ring about 9 inches in diameter. While in the other types of dala the apex is closed and the hauling-in line is

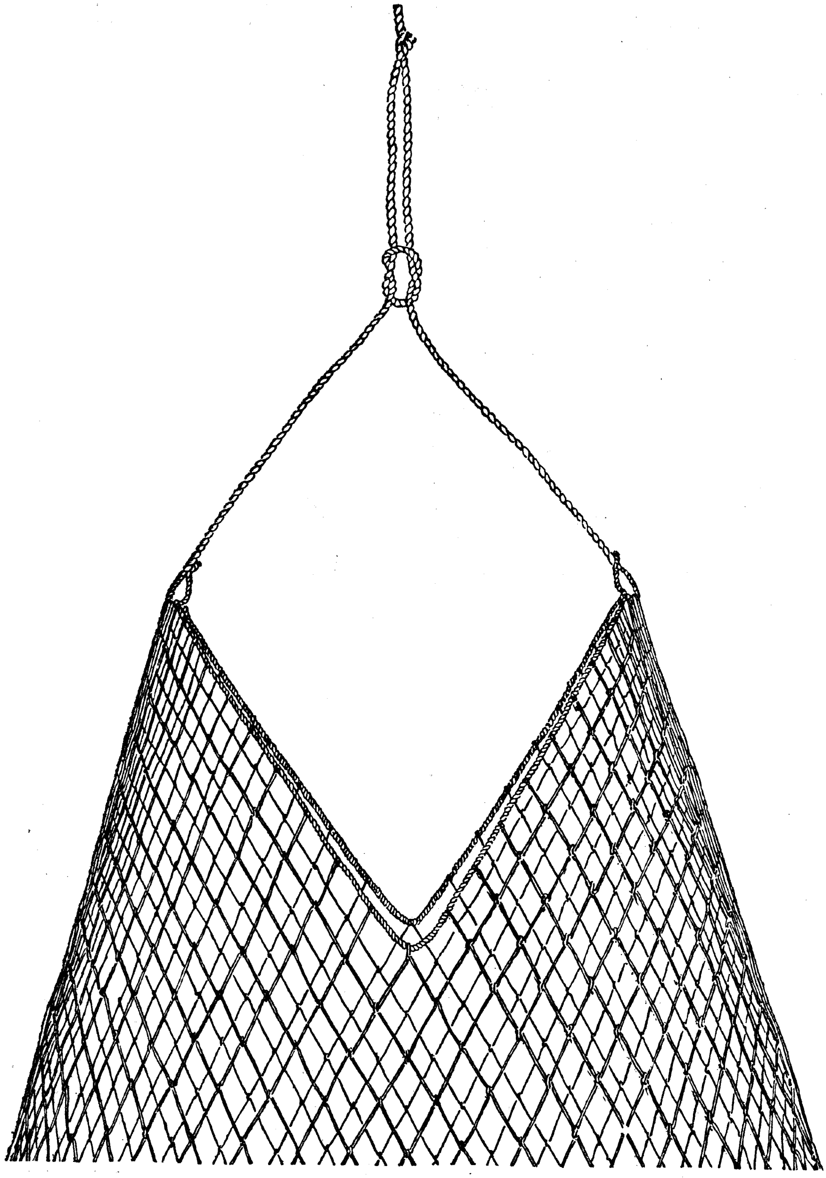

FIG. 5. Apical portion of a pangduhay showing apical V-shaped cut.

more or less directly attached to it, the apical end of this particular dala, which is composed of 72 meshes, has a vertical V-shaped cut (text fig. 5). Twenty-two meshes of the webbing

on each side of the rim of this apical cut are attached to a $\frac{1}{8}$-inch marginal cotton cord. The free ends of these marginal cords together with fourteen meshes on each side of the cut are laced to the eye-splice formed of the free ends of a $\frac{1}{4}$-inch bridle cord about 7 feet long. To the bight of the bridle cord is then attached the hauling-in line proper in the manner shown in the text figure. This opening is especially useful when removing the baited line from inside the cast net during the hauling operation.

The various kinds of deep-water cast nets in use in Manila Bay are the following:

Serial No.	Name of gear.	Kind of twine.	Size of twine; No.
1	Pangsiliniast or panglamok	Linen	50 and 40.
2	Malimit na pamulang usô	do	50 and 40.
3	Pamulang usong talaga	do	50 and 40.
4	Pang-alañgan	do	50 and 40.
5	Malimit na panghalobaybay	do	50 and 40.
6	Panghalobaybay or pangtunsoy	do	50 and 40.
7	Panamban	do	28.
8	Pangduhay	China grass	$\frac{1}{32}''$ to $\frac{1}{16}''$ diam.

Serial No.	Size of stretched mesh.	Fish caught.	Price of net.	Season of operation.
	in.		*Pesos.*	
1	$\frac{1}{2}$	Young herrings	42	February to May.
2	$\frac{5}{8}$	Small herrings	30	Do.
3	$\frac{3}{4}$	do	27	Do.
4	$\frac{7}{8}$	Herrings of intermediate size	25	Do.
5	$\frac{15}{16}$	Medium-sized deep-bodied herrings	25	June to December.
6	1	Adult herrings	20	Do.
7	$1\frac{3}{4}$	Adult sardines	20	Do.
8	$3\frac{1}{2}$	Pomfrets	15	October to December.

METHOD OF OPERATION

The fishing boats leave port for the fishing ground (different points around the Bay) early in the morning. Upon arrival at the fishing ground, they reconnoiter for schools of pelagic fishes, usually herrings. The net caster, who stations himself in the prow of the boat, making use of the wooden platform as his stage, scouts for the schooling fishes.

When such a school is sighted, he signals to the steersman to direct the boat towards it. He then prepares a net for casting. This he does by coiling the hauling-in line on the platform. Then he piles the net in folds. Grasping the folds of netting

with the right hand (in the case of a right-handed fisherman) he arranges the lower marginal edge of the cast net so as not to entangle the sinkers and at the same time make a perfect spread of the net. With his right arm he supports a portion of this edge of the net towards the right. He then spreads apart the remaining lower edge towards his left with the left hand. In this position (Plate 1, fig. 2) he waits until the boat approaches the vicinity of the school.

In the meanwhile, when the boat is about sixty feet from the school, the rowers change their oars for the paddles in order that they may approach it as close as possible with the least

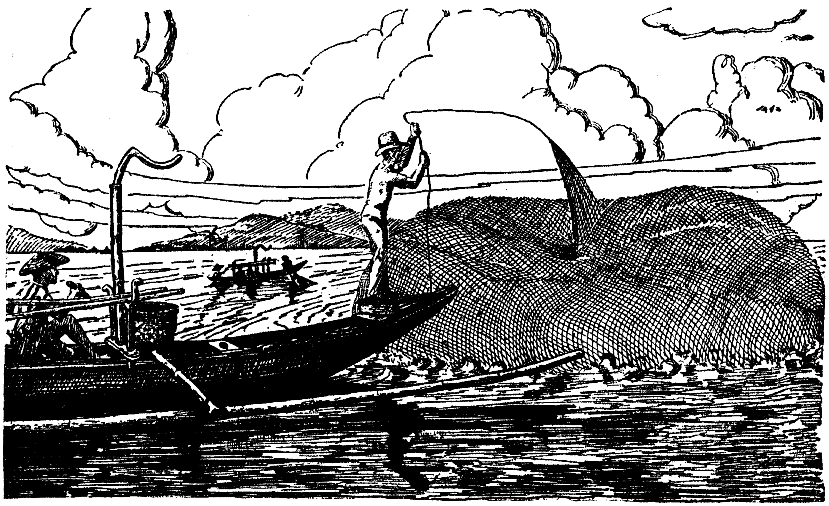

FIG. 6. The deep-water dala in operation.

disturbance of the water. No unnecessary motions and disturbances are made during this phase of the operation, as a slight movement is enough to frighten the fish away.

The caster determines the movement of the school and at the same time locates its head. The boat is then maneuvered to have the school head towards it. When within the reach of his throw, he casts the net with a deft half-swing of the body—whereby it is thrown forward, opening out gracefully in an almost perfect circle (Plate 1, fig. 3; Plate 2, fig. 2; and text fig. 6). As the weighted edge sinks, the net is dragged forward—whereupon a considerable length of the retrieving line is released. The fishes are impounded and usually gilled in the twine as the net settles.

The thrower begins to haul in the cast net by pulling or drawing on board the hauling-in line from the side of the boat (Plate 2, fig. 1). While thus being drawn, the edges come together, collapsing the side of the spread net, thus insuring to a greater extent the inclosing and the gilling of the fishes. The cast net proper, with the impounded and the gilled fishes, is hauled in (Plate 2, fig. 3). It is then hung on the hooklike pole and the fish are removed by one or more fishermen (Plate 3, figs. 1 and 2).

Th oarsmen again row the boat at full speed to locate another school of fish and the operation is repeated.

As each boat carries from seven to eight nets, successive throws are made, depending upon the abundance of the schools of such fishes. The gilled fishes are quickly removed, so that the net can be cast again.

While this description holds true with the majority of the dala, the pangduhay is operated in a somewhat different manner. In the case of this gear, the baited lines are first set at various points in the fishing ground. From time to time these lines are examined to ascertain the presence of a fair number of pomfrets. This is done by dipping the float of the line with the aid of the pamangkao (the long-handled scoop), slightly lifting the baited end with care. When a good number of such fishes have been attracted, the line is cautiously returned to its original position in the water. The dala is then thrown over the baited line impounding and gilling the pomfrets. In the hauling process, this accessory apparatus is removed through the V-shaped opening of the apical edge. Then the whole net is hove up from one side of the boat and the catch picked from its meshes.

THE CATCH

The catch, composed of small and medium-sized pelagic species that run in schools, is then placed in bamboo baskets.

The most important species caught are the sardines (*tamban* when full grown and *tamban siâ* when immature), *Harengula longiceps* Cuv. and Val.; the round-bodied herring (*tunsoy* when full grown and *siliniasî* when young), *Harengula molluccensis* Bleeker; and the deep-bodied herring (*lapad* or *halobaybay* when full grown and *bagasbas* when young), *Harengula fimbriata* Cuv. and Val. Sometimes small quantities of slipmouths (*sapsap, e-im, dalañgat,* and *hualing*), *Leiognathus* spp.,

are included in the hauls. Pomfrets (*duhay*), *Stromateus niger* (Bloch), comprise the pangduhay catches.

Although some casts are entirely fruitless, the majority of the hauls bring fairly good catches—at times, very abundant within a short period of actual fishing. These catches are disposed of at the nearest local market, as they are never iced. When extraordinarily large, however, they are taken to Umbuyan (that section of Tondo where the smoke houses are located) where they are sold wholesale to Chinese owners of smoke houses.

ILLUSTRATIONS

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PLATE 1.

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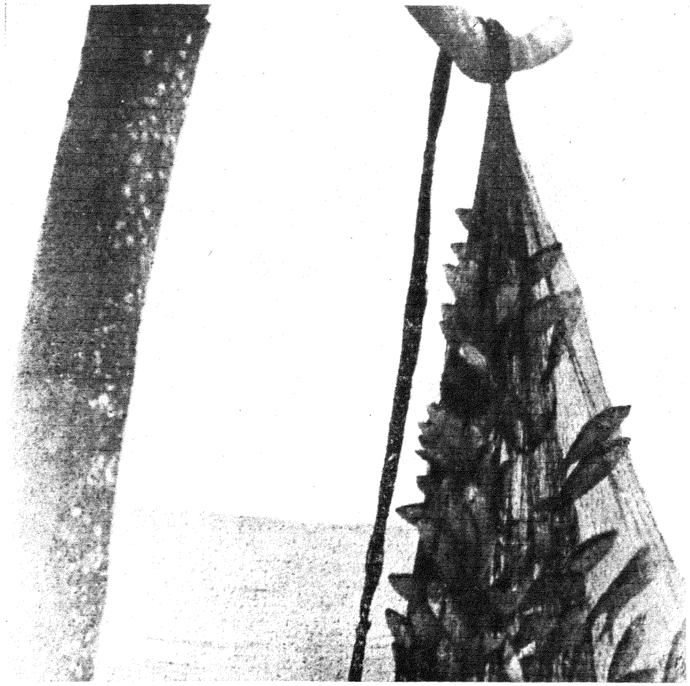
PLATE 2.



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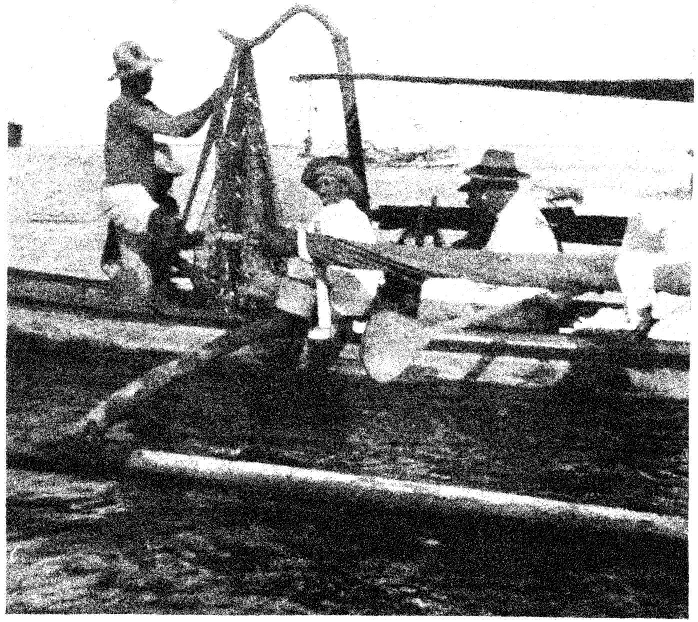

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PLATE 3.

THE NUTRITIVE PROTEIN VALUE OF FIVE VARIETIES OF RICE

By A. J. HERMANO
Of the Bureau of Science, Manila

SIX TEXT FIGURES

Rice constitutes the chief staple food of the inhabitants of the Philippine Islands and other Oriental countries; such as, Japan, China, Siam, India, the Dutch East Indies, and the Malay Peninsula. There are many varieties and very little attention and study have been devoted to the proper variety selection with regard to the biological value of the protein content. A variety of rice with low protein content might possess more nutritive value than others with a higher protein content.

Wells, Agcaoili, and Feliciano [1] reported that scientific control of fertilizers, cultural methods, and irrigation are important factors in improving the yield and the quality of rice as to protein and carbohydrate content.

Vedder and Feliciano [2] have shown that amino-nitrogen is useless as a chemical index for beriberi-preventing rice. They proposed, however, the following indices for beriberi-preventing rice: "*Any rice having 1.77 per cent of phosphorus pentoxide plus fat, but not less than 0.4 per cent phosphorus pentoxide; or any rice having not less than 0.62 per cent phosphorus pentoxide; or any rice having not less than 0.50 per cent phosphorus pentoxide and with at least 75 per cent of the external layers of the grain remaining.*"

Suzuki, Matsuyama, and Hashimoto [3] separated pure rice protein and fed it to albino rats. They demonstrated that rats on a diet containing 10 per cent of rice protein never weighed more

[1] Philip. Journ. Sci. **20** (1922) 353–361.
[2] Philip. Journ. Sci. **35** (1928) 351–389.
[3] Institute of Physical and Chemical Research **4** (1925) 1–48.

than 130 grams. Standard growth was obtained, however, by employing 15 per cent or more of rice proteins in the diet.

EXPERIMENTAL PROCEDURE

For this investigation, five varieties of rice were used. Polished samples of Sipot, Mancasar, Ramay, Binicol, and Apostol were supplied by the Bureau of Plant Industry. Each variety of rice was cooked in the same way as the Filipinos boil it for their meals. McCollum's salt mixture No. 185, purified butter fat, and Bureau of Science tikitiki extract were employed in the basal ration used for the experiments as follows: Rice, 86 grams; salt mixture No. 185, 4; butter fat, 5; and tikitiki extract, 5.

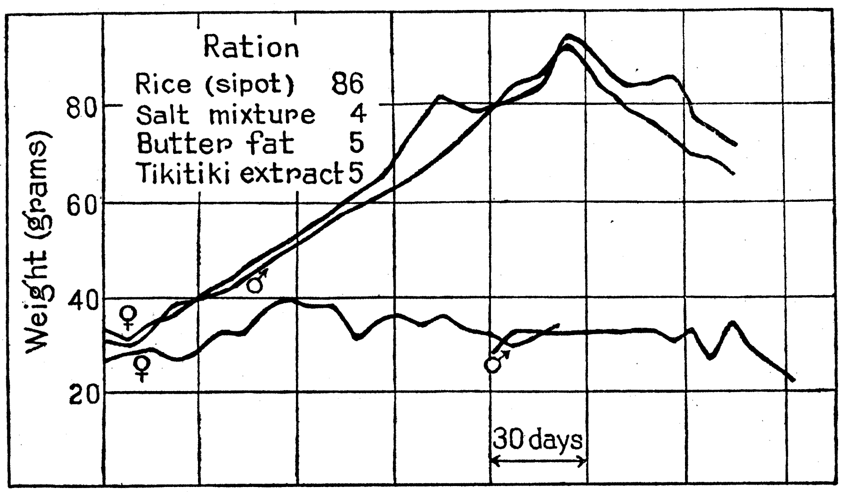

FIG. 1. Weight curves of albino rats fed on Sipot rice as the source of proteins.

The chemical analyses of the rice samples were made according to the methods of the Association of Official Agricultural Chemists.[4] The object of the analyses was to ascertain the protein contents of the different varieties of rice.

The biological study was performed on twenty-seven healthy albino rats. Eight rats were used for experiment on the Sipot variety, five for Mancasar, four for Binicol, four for Ramay,

[4] Official and Tentative Methods of Analysis. Association of Official Agricultural Chemists (1925).

and six for Apostol. The animals after weaning were subjected to diets which contained polished rice as the sole source of proteins. The diets were faulty to a certain extent because the total protein contents were below the requirement for normal growth. The proteins were not separated from the rice. Feeding experiments of separated proteins from different varieties of rice remain to be investigated.

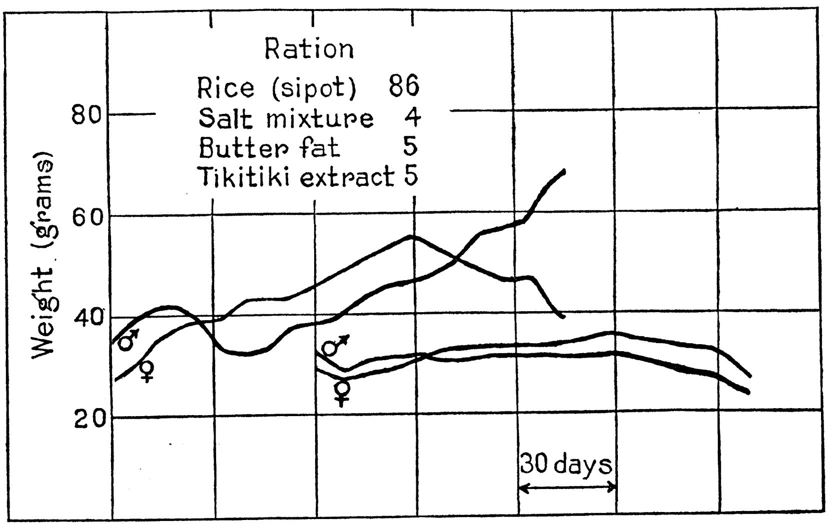

FIG. 2. Weight curves of albino rats fed on Sipot rice as the source of proteins.

RESULTS

Table 1 gives the chemical analyses of five varieties of rice, and text figs. 1 to 6 demonstrate the biological tests on albino rats.

TABLE 1.—*Results of analyses of five varieties of rice.*

Variety.	Moisture.	Protein (Nx6.25).	Ether extract.	Ash.	Carbohydrates (by difference).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Apostol	14.53	8.01	1.56	1.29	74.61
Binicol	12.75	8.32	0.84	1.54	76.55
Mancasar	11.39	7.11	0.85	0.61	80.04
Ramay	11.81	6.20	0.65	0.54	80.80
Sipot	11.22	11.54	0.61	0.73	76.90

TABLE 2.—*Nutritive value of five varieties of rice.*

Variety of rice.	Total protein.	Rats used.	Maximum body weight.	Duration of experiments.	Remarks.
	Per cent.		*g.*	*Days.*	
Apostol	8.01	6	72.0	108–204	Five of the six rats employed in the experiments did not reach 45 grams though one weighed 73.5 grams.
Binicol	8.32	4	69.0	93–133	One rat reached the weight of 69 grams and the other three were stunted.
Mancasar	7.11	5	104.3	94–153	Two of the five rats reached the weights of 82 and 104.3 grams, respectively. One rat died of respiratory disease.
Ramay	6.20	4	75.0	123–207	One rat reached a weight of 75 grams, and one died of respiratory disease.
Sipot	11.54	8	94.3	93–195	Two of the eight rats used in the experiment reached the weight of 93 and 94.3 grams, respectively. Four were stunted and one died of loss of weight.

As shown by the data in Table 1, the protein contents of the five varieties of rice were found to vary from 6.20 to 11.54 per cent.

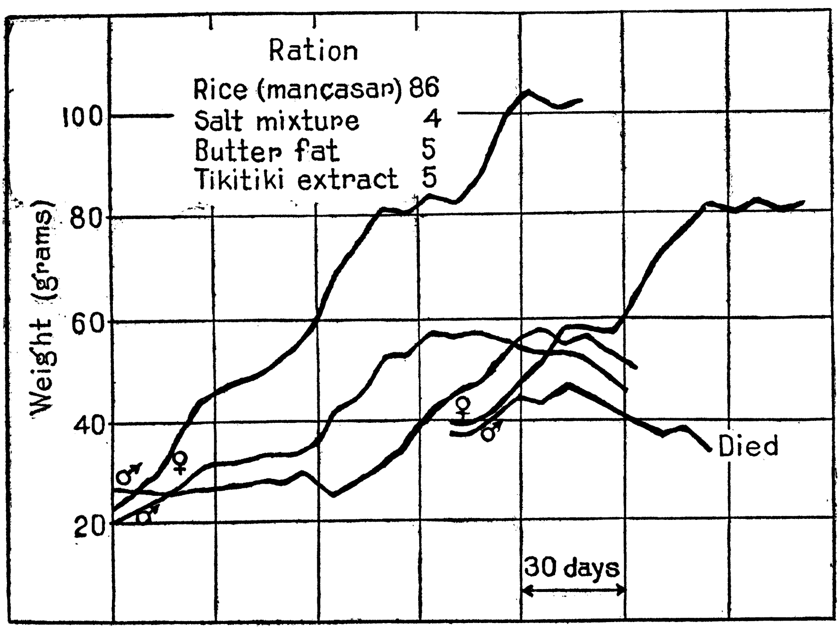

FIG. 3. Weight curves of albino rats fed on Mancasar rice as the source of proteins.

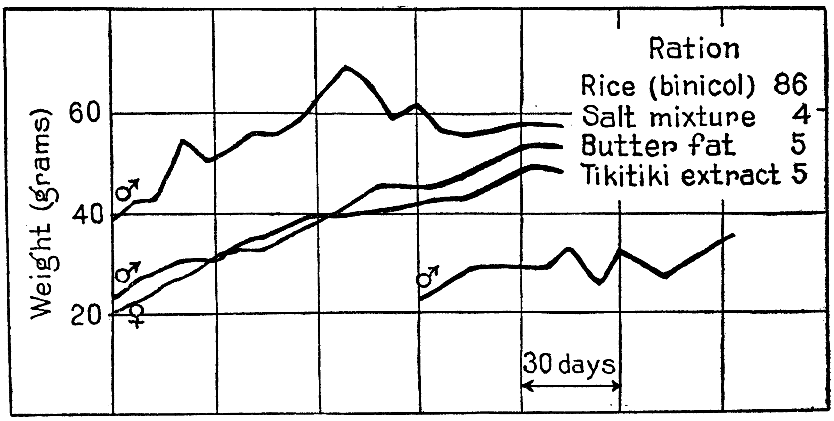

FIG. 4. Weight curves of albino rats fed on Binicol rice as the source of proteins.

The growth curves of figs. 1 to 6 indicate that rice as the sole source of protein in the diets was not adequate to meet the needs of the rats. The animals were stunted and never weighed more than 104 grams, which is an indication that the diets were deficient in protein requirement.

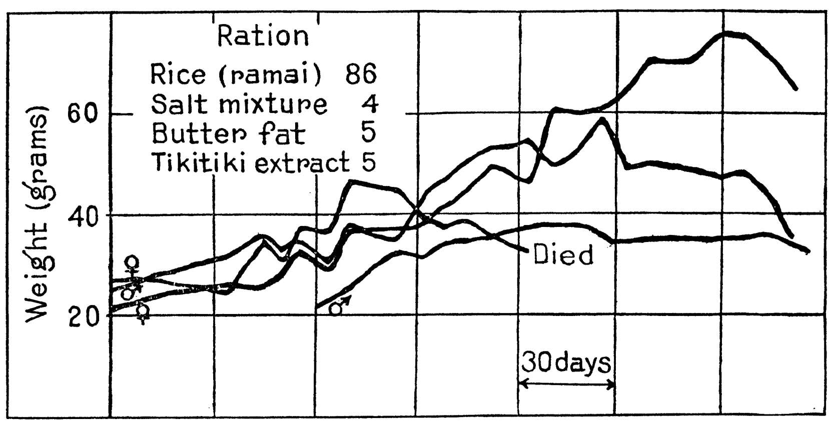

FIG. 5. Weight curves of albino rats fed on Ramay rice as the source of proteins.

The curves of figs. 1 and 2 illustrate the growth of the rats fed on diets the protein of which was derived entirely from sipot rice. The protein content in the diet was approximately 10.30 per cent.

The curves of fig. 3 show the growth of the rats fed on diets the protein of which was derived from Mancasar rice. The pro-

tein content in the diet was approximately 7.49 per cent. Although the protein content was lower than in the diets containing Sipot, Binicol, and Apostol, two rats grew larger than the other animals fed with the same amount of rice.

The chart for Ramay rice shows that Ramay has a low nutritive value.

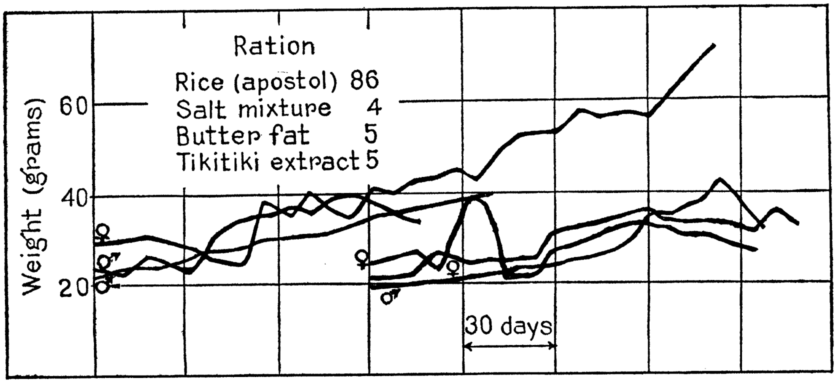

FIG. 6. Weight curves of albino rats fed on Apostol rice as the source of proteins.

SUMMARY

1. The chemical constituents and the nutritive protein value of five varieties of rice were determined.

2. Mancasar was found to contain less protein, but its nutritive value seemed to be greater than that of Apostol, Binicol, and Sipot.

3. Ramay was found to contain the least amount of protein but its nutritive value appeared to be higher than that of Apostol and Binicol.

ILLUSTRATIONS

TEXT FIGURES

TWO FRESH-WATER SHELLS FROM THE PHILIPPINE ISLANDS

By LEOPOLDO A. FAUSTINO
Chief, National Museum Division, Bureau of Science, Manila

TWO TEXT FIGURES

In the course of his investigations of the intermediate molluscan hosts of human flukes Dr. M. Tubangui, of the division of biological laboratory, Bureau of Science, encountered two fresh-water mollusks that have not been reported from the Philippine Islands. These shells were given me for identification, and I am glad to have the opportunity to report on them.

GYRAULUS PRASHADI sp. nov. Fig. 1.

Shell discoidal, small, thin, somewhat flat, transparent or translucent, whorls five, rounded, closely and obliquely striated, peri-

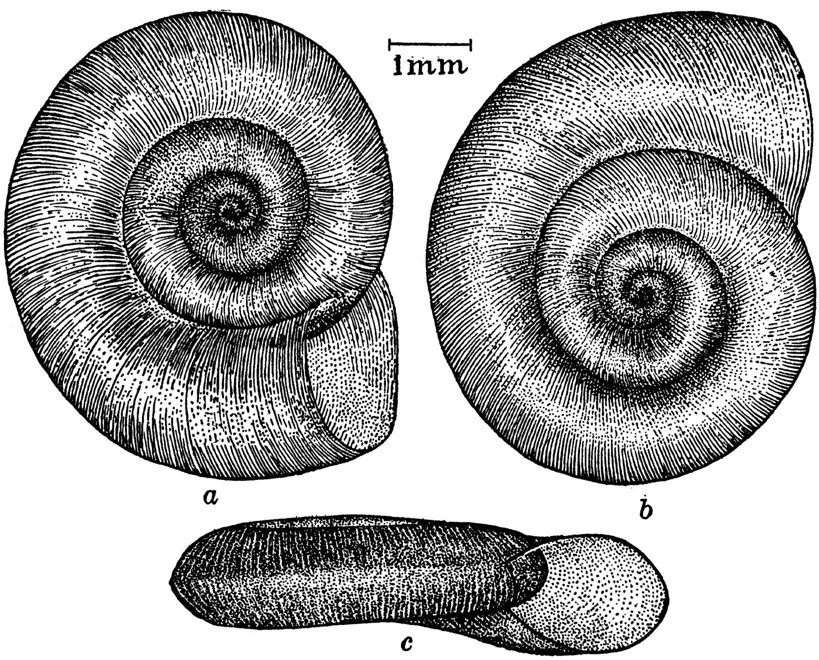

FIG. 1. *Gyraulus prashadi* sp. nov.

phery subangular, spire depressed, aperture egg-shaped. A few of the specimens are black due to the habitat.

Height, 1 millimeter; maximum diameter, 5.

Locality.—San Antonio, Zambales Province, Luzon; also in ponds around Manila and vicinity; collected by M. Tubangui.

Type.—Bureau of Science No. 14404.

This species differs from *G. convexiusculus* (Hutton), which it closely resembles, in having more whorls; and in the shape of

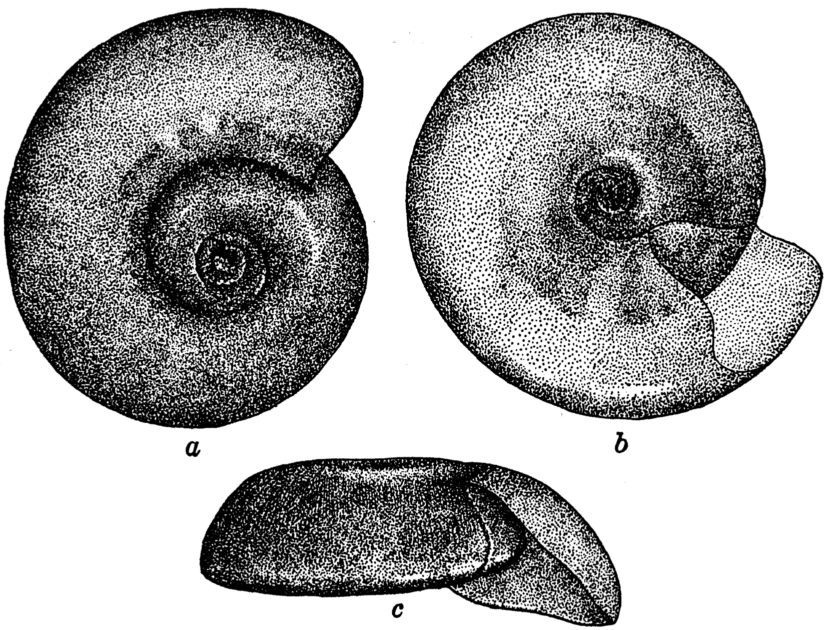

FIG. 2. *Hippeutis umbilicalis* (Benson.)

the mouth, which is more oviform. It differs from *G. euphraticus* Mousson in being more convex and in having the whorls more rounded, in having an egg-shaped aperture and in having the angle on the middle of the outer lip not pronounced but more like that of *G. convexiusculus* (Hutton). Doctor Prashad, of the Zoölogical Survey of India, was the one who called my attention to the fact that this species is distinct from *G. euphraticus* Mousson or *G. compressus* Hutton to which I had previously assigned the lot of specimens given me for identification. It is with pleasure that I name this species after him.

HIPPEUTIS UMBILICALIS (Benson). Fig. 2.

1837. *Planorbis umbilicalis* BENSON, Journ. As. Soc. Bengal 5: 471.
1921. *Hippeutis* (?) *umbilicalis* ANNANDALE, Rec. Indian Mus. 22: 584.

Shell discoidal, nautiliform, thin, transparent, tumid above, somewhat flat below, keeled below the middle, whorls four, last whorl large and broad, spire narrow and depressed, aperture obliquely broad, umbilicus nearly enveloped.

Height, 2 millimeters; maximum diameter, 7.

Locality.—San Antonio, Zambales Province, Luzon, collected by M. Tubangui, Bureau of Science No. 14405; Sitio Napayacan, Buguey, Cagayan Province, Luzon, Bureau of Science No. 3076.

ILLUSTRATIONS

TEXT FIGURES

THE LIFE HISTORY OF THE HUMAN INTESTINAL FLUKE, EUPARYPHIUM ILOCANUM (GARRISON, 1908)

By MARCOS A. TUBANGUI and ANTONIO M. PASCO
*Of the Division of Biology and Serum Laboratory, Bureau of Science
Manila*

FOUR PLATES AND ONE TEXT FIGURE

INTRODUCTION

The following considerations were mainly responsible for taking up the study of the life history of *Euparyphium ilocanum* (Garrison, 1908) (=*Echinostoma ilocanum*): to determine the mode of transmission of the parasite and to work out as accurately as possible its morphology in the adult stage from properly fixed experimental material. The first consideration was motivated by their inability, when asked, to give specific information on the prophylaxis of the worm. In addition, if its mode of transmission were known, it might be possible to explain from epidemiological observations the apparently limited geographical distribution of the parasite in man in the Philippine Islands.

As Tubangui (1931) pointed out in another paper, the available descriptions of *Euparyphium ilocanum* were based on material obtained from human beings after anthelmintic treatment and such specimens may not have represented accurately the anatomical features of the parasite. For this reason it is desirable that the morphology of the fluke be known definitely so that the identity of the trematode reported by Tubangui (1931) as *Euparyphium ilocanum* from the wild rat may be verified.

HISTORICAL

The Philippine intestinal fluke was discovered by Garrison (1908), who first found the ova of the parasite in the stools of five out of over five thousand prisoners in Bilibid Prison, Manila.

Later he recovered twenty-one specimens of the adult worm from one of the infested persons after the administration of male fern as an anthelmintic. Garrison described the fluke as *Fascioletta ilocana* under the supposition that it represented not only a new species but also a new genus of trematode. Odhner (1911), however, who received four specimens from Garrison's type material, at once recognized the systematic affinities of the worm and transferred it to the genus *Echinostoma* (Rudolphi) (=*Echinostomum*).

Following Garrison's discovery, other human cases of infestation with the parasite were reported by a number of investigators. In view of the common occurrence of echinostomes in general in the intestines of birds and of the successful development in man and other mammals of certain species of avian heterophyids, as reported by Faust and Nishigori (1926) and others, some observers began to suspect that the fluke in question might be a normal bird parasite that is only accidentally transmitted to human beings. No thought was entertained that the trematode might be harbored by a mammal other than man, as was suspected by Leiper (1911) in the case of *Euparyphium malayanum*, until Tubangui (1931) found what was apparently the same species of fluke in the intestine of the wild rat, *Mus norvegicus*. Before this, Majima (1927) in Japan had reported a human case of infestation with a related rat trematode, *Echinostoma macrorchis* Ando and Ozaki, 1923.

On the basis of material obtained from rats, Tubangui redescribed the parasite and placed it in the genus *Euparyphium* Dietz, 1909, due mainly to the presence of spines on the two body surfaces. Without taking it into account then, it is now found that the combination *Euparyphium ilocanum* is a resuscitated homonym, having already been used by León (1920) for a trematode, collected by him from a Roumanian peasant, which he thought was identical with the Philippine species. Later the same author and Ciurea (1922) rectified the error by describing the Roumanian parasite as a distinct species under the name *Euparyphium jassyense*.

GEOGRAPHICAL DISTRIBUTION

Garrison's fluke has so far been found only in the Philippines. Formerly, it was believed to be limited in its distribution to the northwestern provinces of Luzon, but its presence in wild rats in Manila, as already mentioned, indicates that it has a wider geographical range.

In man, however, as shown in the following review of recorded cases, it has been reported only from northwestern Luzon or, more accurately, from the Ilocano portion of the Philippine population. To begin with, the first five cases seen by Garrison (1908) were all natives of Ilocos Sur, so that this province is the type locality of the parasite. Willets (1911), during a parasitological survey in Cagayan Valley, found a case of trematode infection in a boy 13 years of age that was most probably due to *Euparyphium ilocanum.* Willets did not exactly state the province from which the boy came, but in his introductory remarks he said that "nearly all of the persons examined were Ilocanos who migrated into the Cagayan Valley."

Hilario and Wharton (1917) next reported five cases, all of whom came from towns in Zambales Province, the population of which includes a large number of Ilocanos. In the examination of the stools of more than five hundred students of the University of the Philippines at Los Baños, Schwartz and Tubangui (1922) found two cases, one of whom was a native of Zambales and the other of Ilocos Sur. From another set of students in the same institution Tubangui and Francisco (1925) detected four other cases, all of whom were Ilocanos. One was from Ilocos Sur, two from Zambales, and one from Pangasinan.

When this investigation on the life history of the parasite was started, surveys were made in several places in northwestern Luzon for the purpose of obtaining egg material for experimental infection of snails. In San Antonio, Zambales, of thirty adult people examined, eight harbored the parasite. In Tagudin, Ilocos Sur, where ninety-one high-school students were examined, seven positive cases were detected. On the other hand, in the adjoining Province of Abra, where forty-eight students of the Lagangilang Agricultural High School and eighteen Tinguians residing in Barrio Villaviciosa, Bangued, submitted fæcal samples for examination, not a single case was found. It would appear, therefore, that the parasite does not exist in Abra, although we are told by Dr. Zacarias de Jesus, assistant professor of veterinary parasitology in the University of the Philippines, that on one occasion he encountered the eggs of the fluke in the stools of a servant girl from that province.

METHODS

This work on the life cycle of *Euparyphium ilocanum* was part of a program to determine the molluscan intermediate hosts of the trematodes found in man and in domesticated

animals in the Philippines. To carry out this program, collections of common species of fresh-water snails were made and these were allowed to breed in small balanced aquaria under laboratory conditions. The purpose of this was, of course, to have on hand clean snails for infection experiments with known trematode larvæ (miracidia) whenever the latter became available.

The eggs of the parasite were obtained from time to time from two heavily infested cases residing in San Antonio, Zambales. The stools, after the usual preliminary screening, washing, and sedimentation processes, were placed with small amounts of ordinary tap water in shallow glass dishes and kept in improvised humidors at a room temperature of 26° to 31°C. In such an environment the majority of the ova went through their full development readily and on hatching liberated active miracidia.

The mollusk which is capable of playing the rôle of primary intermediary host was determined by placing active miracidia in the water containing the experimental snails. From time to time thereafter several individuals of the latter were crushed and examined for the presence of trematode larvæ. In the beginning large numbers of miracidia were used in infecting snails. After the discovery of the primary intermediate hosts, it was found necessary to use only a limited number, approximately in the proportion of one miracidium to one snail; otherwise many, if not all, of the snails died before the larvæ had had the chance to reach their full development, apparently as the result of heavy infestations.

The adult stage of the fluke was obtained by feeding infective larvæ (encysted metacercariæ) to clean laboratory white rats, cats, and monkeys.

After establishing the life history of the parasite by the use of aquarium-bred snails, field surveys were made in San Antonio, Zambales, for the purpose of collecting naturally infested mollusks and finding out how the worm is transmitted to human beings. The data obtained were used to check the laboratory findings.

In the study of the larval stages both fresh and stained specimens were utilized. In addition observations on the behavior of the miracidium in the prepared juices of different species of snails were made. Snail juice was prepared by triturating one or several individuals of a particular species of

snail in a small dish or mortar, with or without their shells, into a more or less compact mass and allowing the juice to separate by tilting the container. By means of a capillary pipette one or more miracidia were transferred to a slide with a minimum amount of water. After adding a drop of the snail juice a cover slip was put on and the slide examined under a microscope.

THE MOLLUSCAN INTERMEDIATE HOSTS

Primary intermediate host.—The following species of fresh-water snails were tested with the miracidium of *Euparyphium ilocanum: Pila luzonica* (Reeve), *Vivipara burroughiana* Lea, *Thiara asperata* (Lamarck), *Amphipeplea quadrasi* Moellendorff, *Bulinus hungerfordianus* Nevill, *Lymnaea peregra* (Mueller), *Planorbis umbilicalis* Benson, and *Gyraulus prashadi* Faustino, 1933 (Plate 4, fig. 3).[1] Of these snails only the last species was found capable of playing the rôle of primary intermediate host. In this snail the miracidium after penetration proceeded to develop and passed through stages that are characteristic of echinostomes in general.

Secondary intermediate hosts.—The cercaria of *Euparyphium ilocanum,* like the cercariæ of other echinostomes, assumes the infective stage by undergoing a process of encystment and becoming transformed into a metacercaria. The discovery of its place of encystment was quite accidental. Due to a shortage of aquarium jars we had to place together in one of the experimental jars *Gyraulus* and *Bulinus* and in another jar *Gyraulus* and *Lymnaea* snails. The subsequent examination of these mollusks revealed the presence of rediæ, cercariæ, and occasionally encysted metacercariæ in *Gyraulus prashadi* and only encysted metacercariæ in the other kinds of snails. This observation served as a clue and was later verified experimentally by placing together in small amounts of water cercariæ and clean

[1] In the abstract of this paper contributed to the Eighth Annual Meeting of the American Society of Parasitologists and published in the Journal of Parasitology **19** (1932) 166, *Planorbis umbilicalis* was mentioned as one of the primary intermediate hosts of the parasite. This is a mistake and was due to the hasty identification of snails during their examination for the larval stages of the fluke. It also transpires that the shells which were believed to be *Planorbis compressus* represent a newly discovered species, *Gyraulus prashadi,* which is described by Dr. L. A. Faustino in a preceding paper in this issue of the Philippine Journal of Science.

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snails and watching the disappearance of the former due to their entrance into the bodies of the latter. The snails always showed the presence of encysted metacercariæ when examined the following day. It was determined by such experiments that any of the species of fresh-water snails enumerated above, including *Gyraulus prashadi,* is acceptable as a second intermediate host.

FEEDING EXPERIMENTS

As stated above, the encysted metacercaria represents the infective stage in the life cycle of the parasite in so far as the infection of the mammalian or definitive host is concerned. If fed to such a host, it will proceed to develop to the adult stage in the small intestine of the latter. Below are given briefly the results of some of the feeding experiments. The incubation period, that is, the number of days that elapsed from the time the metacercariæ were fed until the eggs of the parasite first appeared in the fæces of the experimental animals, was 7 to 10 days in fourteen rats; 12 to 16 days in two monkeys; and 15 days in one young cat. In these animals the infection was of short duration, the eggs disappearing from their fæces after one to two weeks. Whether this phenomenon is due to the fluke being naturally short-lived or to its not being well adapted to these hosts, has not been determined. In human beings the worm seems capable of staying for a number of years. Metacercariæ were also fed to two pigeons and one pup, but the results were negative.

Experiment 1.—August 2, 1932. Rats 1 and 2 fed experimental *Bulinus* snails containing encysted metacercariæ.

August 10. Rats 1 and 2 showed trematode eggs in fæces. Rat 1 was killed August 15 and from the anterior portion of its small intestine seventeen adult specimens of *Euparyphium ilocanum* were collected. Rat 2 was killed August 16 and yielded eighty-two adult flukes.

Experiment 6.—November 4. Four snails (*Pila luzonica*) collected from a fishpond in San Antonio, Zambales, Luzon, in which many individuals of *Gyraulus prashadi* harboring the cercaria of *Euparyphium ilocanum* were found, were placed in the cage of starved rats 7 and 8. The rats gnawed through the shells of the snails and ate the soft parts.

November 11. Rat 8 showed trematode eggs in fæces. Killed November 15 and yielded sixty-five adult *Euparyphium ilocanum.*

November 14. Rat 7 positive. It became negative November 21 and when it was killed no flukes were found in the intestines.

Experiment 8.—November 7. Monkey 1 was fed experimental *Pila* snails containing encysted metacercariæ.

November 16. Negative; fed again encysted metacercariæ.

November 28. Trematode ova found in fæces. Killed December 1 and yielded eleven adult *Euparyphium.*

Experiment 10.—December 14. Cat 1 given encysted metacercariæ found in experimental *Pila* snails.

December 29. Trematode eggs found in fæces. This cat was allowed to live and was positive up to January 11, 1933. The next day the fæces were negative, and when the animal was killed no flukes were found in the digestive tract.

STAGES OF THE LIFE CYCLE

THE EGG

Description.—The eggs are refractive, oval bodies with a faint tinge of yellow. Subspherical and even elongate forms were occasionally encountered, but these proved in the majority of cases to be infertile and may, therefore, be considered as abnormal. The size in microns has been given by the different observers cited above as follows: Garrison, 88.8 to 114.7 by 53.5 to 81.9; Odhner, 92 to 114 by 53 to 82; Hilario and Wharton, 88.8 to 111 by 53.6 to 74.4; Tubangui, 85.5 to 101.5 by 54 to 64.2. The present findings agree with these figures in showing the variability in the size of the ova. One hundred eggs found in the stools of four infested individuals and measured at random, gave the following results in microns: Length 83.2 to 116.4, maximum width 58.2 to 69.7, the average size being 96.1 by 63.4. The same number of eggs measured from the fæces of the experimental rats and monkeys gave results that are very close to these figures.

The eggshell (Plate 1, fig. 1) is smooth, operculated at one pole, and double-contoured in optical section. It is, however, quite transparent and uniformly thin except for a more or less distinct thickening at the pole opposite the operculum. The latter is a small concavo-convex disk with a finely serrated edge that dovetails into the margin of the shell opening. It measures 18.5 to 21 microns in diameter.

The germinal area is a globular mass, about 16.5 microns in diameter; it is usually located behind the equator of the egg towards the nonoperculated end. It stands out rather indistinctly from the numerous yolk balls that surround it by its greater opacity and grayish color. The yolk balls are filled with a brownish granular material. The germinal area and yolk balls are contained in a vitelline sac that lies so close to the interior of the eggshell that its presence in the undeveloped egg is difficult to demonstrate. When the miracidium is formed, its presence is made evident during the movements of the larva.

Development.—In freshly voided fæces the eggs are usually in the one-cell stage (Plate 1, fig. 2); rarely they are in the two-cell stage. When left in tap water at a room temperature of 26° to 31° C. after having been washed and sedimented, their development is rapid. The germinal area divides and passes through the well-known stages of metazoan embryonic development. During the morula stage the eggs present a characteristic picture: the bunch of embryonic cells occupies a central position, surrounded by a network of empty or almost empty spaces (Plate 1, fig. 3). The latter represent the impoverished yolk balls, the contents of which have been gradually used up by the developing embryo. As the miracidium begins to take form, these are crowded out gradually and oillike globules, which possibly represent excretory products, make their appearance. When the miracidium is fully formed, there are two or three large ones of these globules abutting the larvæ (Plate 1, fig. 4).

The majority of eggs were observed to attain the miracidial stage after six to fifteen days, others after a prolonged incubation period of five to six weeks. Hatching ordinarily took place three to five days after the formation of the miracidia.

THE MIRACIDIUM

Description.—The miracidium is similar in appearance to the miracidia of most trematodes. The anterior half of the body is more bulky than the posterior half and is produced anteriorly into a conical retractile papilla. The entire surface, except in the region of the papilla, is covered with long cilia, by means of which the larva is enabled to swim very actively. These cilia arise from definite epidermal cells or plates, of which there are nineteen arranged in four transverse rows (Plate 1, fig. 5). The first row contains six small cells, which are almost triangular

in shape with their apices directed anteriorly; the second row six larger cells that are rectangular with rounded corners; the third row four cells that are also rectangular but are larger than those of the second row; the fourth row three cells that are almost as large as those of the preceding row but are somewhat triangular with their apices directed posteriorly. In the living organism these epidermal cells are arranged very close together, except where two minute lateral processes, one on each side, protrude between the first two rows of cells. In extended specimens killed in hot 10 per cent formalin solution, the cells are seen to be separated from each other by nonciliated spaces.

In the preserved state, with the anterior papilla partly protruded, the miracidium measures 61.5 to 65.5 microns in length by 27.5 to 29.5 microns in maximum breadth. When alive it averages 85 by 35 microns in size. It is provided with a small sacculate gut which reaches to the tip of the papilla by means of a narrow duct. Both the gut and its papilla are conspicuous due to their refractive granular lining. No evidence was obtained to indicate the presence of a patent mouth as has been observed by Barlow (1925) in the miracidium of *Fasciolopsis buski.* Immediately behind the digestive tract on the dorsal surface is a pair of eyes that are discernible due to their inner pigmented portions. The lenses themselves are difficult to distinguish. The eyes are often so close together that the approximation of their pigmented areas gives the impression of the presence of a single X-shaped "eye spot." Ventral and a little posterior to the eyes is a pair of neurons, probably representing the central nervous system. Two flame cells are present near the equator of the body, one on each side of the median line. Each of these excretory cells is provided with a sinuous duct that leads to the exterior through a lateral opening located between the last two rows of epidermal cells. The germinal cells occupy most of the space in the posterior half of the body.

Behaviour in water.—Immediately after hatching the miracidium begins an active life in the water. Its behavior is very much like that of the miracidium of *Fasciolopsis buski,* as described by Barlow (1925). It swims here and there with a spiraling but smooth and graceful motion and with only very momentary stops until it either dies from sheer exhaustion or succeeds in penetrating into the body of an intermediate host. Newly hatched miracidia, kept in a small dish of water floated on the surface of a screened balanced aquarium at 8 to 9 o'clock

in the morning, did not live for more than seven hours. This experiment was repeated six times, and an average longevity of 6 hours 37 minutes was obtained.

Behavior in snail juices.—In view of the interesting observations recorded by Barlow on the behavior of the miracidium of *F. buski* in the expressed juice of its intermediate host, it was considered worth while to observe the behavior of the miracidium of *Euparyphium ilocanum* not only in the juice of its primary intermediate host but also in the juices of the other kinds of snails used in the preliminary infection experiments. Similarly interesting results were obtained. It was noticed that in the juices of the latter mollusks the miracidium reacted indifferently; that is, it behaved as if it were in water with the exception that it was unable to swim as fast due to the viscosity of the medium and to the presence of bits of snail tissues that interferred with its free locomotion.

In the juice of *Gyraulus prashadi,* on the other hand, its reaction was quite different. The following changes, which are possibly identical with those occurring during the act of penetration of the miracidium into the body of a snail, were seen to occur during observation periods lasting from three and a half to four hours: The larva on coming in contact with the fluid of its primary intermediary host seemed to be stimulated, as shown by its jerky and rather hurried movements. After a few moments it quieted down, moving here and there slowly and cautiously. Very soon a part of its epidermis at the anterior end began to bulge in the form of a blister. A few minutes later it remained stationary in one place, but with its cilia moving continuously and the bulging of the epidermis becoming more pronounced. Soon one of the second row of epidermal cells was cast off and carried away by its cilia which continued vibrating long after the epidermal cell was peeled off. Another cell from the same group may next be detached and be carried away by its supply of cilia. In many of the larvæ observed, however, the three remaining cells of this row, instead of being completely cast off like the first one, were merely folded back and remained attached to the third row of cells. Somewhat later the first row of cells was discarded by being pushed forward en masse. Its anterior end being then free, the larva pulled the rest of its body out of the remaining two rows of epidermal cells by means of its active contractions. It assumed a roundish to oval form, the anterior headlike papilla was retracted into the body and the germ cells appeared

more prominent. It had, therefore, the important characteristics of a young sporocyst and may for that reason be appropriately called a miracidium-sporocyst (Plate 2, fig. 1). At the end of three and a half to four hours the larvæ died in spite of attempts to prolong their existence by periodically giving fresh snail juice.

The apparently specific reaction shown by the miracidium of *Euparyphium ilocanum* in the juice of its primary molluscan host raises the question as to whether or not the miracidia of the different species of trematodes will exhibit the same specific behavior if placed in the fluids of their respective intermediary hosts. Experiments with the solution of this question in view would be worth undertaking; and, if positive results were obtained, a useful preliminary technic in the elucidation of the life cycles of flukes in general would be made available.

Penetration of the miracidium into the body of the primary intermediate host.—The mode of penetration of the miracidium into the primary intermediate host was ascertained, as was done by Barlow in the case of *F. buski,* by placing a snail and some water containing miracidia on the depression of a bacteriological "hanging drop" slide under a cover glass. Thus inclosed, the snail makes attempts to escape and in so doing enables one to view its exposed parts under the microscope.

Miracidia were observed to be overactive in the presence of their proper intermediate host. In view of its spiraling mode of locomotion, if a miracidium strikes against any solid body, the sudden impact of its arrested movement causes it to rotate on its long axis with a characteristic boring motion. If it strikes against the shell of its host or any hard object, its arrest is only momentary, the larva soon regaining its balance and darting away as fast as ever. If it happens to hit the body of the snail, it remains as if rooted to the spot for a longer or shorter period of time even after the boring motion of the body has ceased. Those striking against the foot, head, and tentacles of the snail, however, were found to be unable to go deeper into the tissues and were soon brushed off by the movements of these parts against the shell of the mollusk. Only those that happened to strike the mantle lingered longer and seemed able to penetrate deeper. From this observation it is believed that the miracidium normally establishes itself in the body of its snail host by entering the pulmonary chamber through the mantle and possibly also through the pulmonary orifice.

THE REDIÆ

No attempt was made to follow the route of migration and determine in detail the metamorphosis of the miracidium inside the body of the snail. What probably happens is that the larva, after casting off its epidermal cells during the process of penetration, transpasses the mantle wall and enters the pulmonary chamber. From there it works its way through the adjacent soft tissues until it finally reaches the digestive gland of the mollusk. The rediæ have always been found in the latter organ. They occupy a superficial position and are so loosely attached to the liver tissues that the least pressure, as when the shell of an infective snail is broken even very carefully for examination, is sufficient to set a large number of them free into the water.

Two kinds of rediæ are distinguished: namely, primary or mother rediæ and secondary or daughter rediæ, which in appearance and general structure do not differ materially from other echinostome rediæ; such as, for example, those of *Euparyphium murinum* and *Echinostoma revolutum,* as described by Tubangui (1932). No constant differences were observed to exist between the two kinds of rediæ, except that the mother rediæ (Plate 2, fig. 3) were always found to contain in their body cavities only daughter rediæ and the latter (Plate 2, fig. 4) only cercariæ.

The young rediæ (Plate 2, fig. 2); that is, those inclosing undifferentiated germ balls recently detached from the germinal epithelium of the body cavity, are very small compared with those containing mature or nearly mature rediæ or cercariæ. The body is colorless or, at most, tinted with very pale yellow; the rhabdocœle gut and locomotor appendages are prominent; and the collar is located relatively far from the anterior end. In older rediæ the body is generally colored either partly or wholly with various shades of yellow and brown, the rhabdocœle gut is relatively small and filled with a blackish material, the locomotor appendages are not very conspicuous, and the collar is pushed nearer the anterior end of the body. A mature mother redia contains from three to twenty daughter rediæ in different stages of development and a mature daughter rediæ from three to twenty-five cercariæ, also in different stages of development. Measurements taken of preserved specimens killed in hot 10 per cent formalin solution gave the following data in millimeters: Young rediæ,

length 0.175 to 0.250, maximum diameter in front of locomotor appendages 0.040 to 0.056, pharynx 0.020 to 0.025 across; older rediæ, length 0.325 to 1.15, maximum diameter 0.108 to 0.165, pharynx 0.04 to 0.06 across.

It was found difficult to determine accurately the details of the excretory system of the rediæ. The number of the flame cells seems to depend upon the age or stage of development of the larva. Their arrangement, however, is basically constant in being bilaterally symmetrical, the cells on either side being arranged into an anterior and a posterior group. In a small daughter redia, harboring three cercariæ, there were seen twelve flame cells on each side with their short and slightly tortuous ducts. The excretory pores are lateral, one on each side, immediately in front of the corresponding locomotor appendage (Plate 2, fig. 5).

THE CERCARIA

Description.—The cercaria of *Euparyphium ilocanum* (Plate 3, figs. 1 and 2) can be recognized at a glance through the microscope as that of an echinostome due to the presence of a head collar, a pair of prominent excretory collecting tubes filled with concretionlike bodies, and numerous cystogenous glands. It possesses the characters of the "Echinata" group of echinostome cercariæ proposed by Sewell (1922) and is most closely allied with that author's Cercaria Indicae XII found in *Gyraulus euphraticus* and *Indoplanorbis exustus.* The first snail, it will be noted, is congeneric with the primary molluscan host of the Philippine fluke.

The body and, to a lesser extent, the tail, like those of most cercariæ, are capable of marked extension and contraction, for which reason it is difficult to give their dimensions accurately. In free-swimming larvæ the body is pyriform and generally shorter than the tail. In preserved specimens this shape may be retained or the body may become elongate, in which case it may be even longer than the caudal appendage. Measurements based on such preserved material gave the following figures in millimeters: Body, length 0.18 to 0.30, maximum diameter (across acetabulum) 0.10 to 0.13; tail, length 0.13 to 0.35, maximum diameter (near base) 0.035 to 0.050; cephalic collar 0.075 to 0.098 across; oral sucker 0.040 to 0.062 by 0.045 to 0.070; prepharynx 0.012 to 0.020 long; pharynx 0.020 to 0.025 across; œsophagus 0.04 to 0.10 long; acetabulum 0.045 to 0.066 by 0.050 to 0.062. The oral sucker is antero-subterminal, while

the acetabulum is between the middle and last third of the body length. The œsophagus divides in front of the acetabulum into two simple cæca that extend near the posterior end of the body. Both the œsophagus and cæca are composed of single columns of cells, the shape of which, depending upon the state of contraction or relaxation of the body, may be either square or rectangular. The reniform cephalic collar is armed with fifty-one spines arranged in two alternating rows uninterrupted dorsally. These collar spines are delicately needle-shaped and are of about the same size, 8 to 10 microns in length. The body surface behind the collar is beset with numerous minute spines, directed posteriorly and arranged in transverse rows. Beneath the cuticle from immediately behind the level of the pharynx to the posterior end of the body are numerous cystogenous glands. These are transversely oval, pear-shaped or roundish bodies, measuring about 12.5 microns across and filled with a finely granular material which renders obscure the outlines of the other structures in the body. The genital anlage is represented by two masses of cells, one in front and the other behind the acetabulum, connected by a narrow strip of cells passing dorsal to the acetabulum.

The excretory system (Plate 3, fig. 3) is typical of echinostomes in general arrangement. There is a median, contractile, excretory bladder near the posterior end of the body that communicates with the outside through a posterodorsal excretory pore. A posterior collecting tube originates from the posterior portion of the bladder; a short distance behind the base of the tail, this tube divides into two branches, each of which opens outside through a lateral pore. The excretory bladder is constricted at its anterior portion and thus gives rise to a small secondary bladder, from which the two principal excretory vessels, the main lateral collecting tubes, arise. The latter follow an anterior zigzag course on each side of the body; at first they are narrow in diameter, but in front of the middle level of the acetabulum they are dilated and filled with globular refractive bodies, the presence of which render these tubes very conspicuous. Each of these tubes on reaching the region of the cephalic collar becomes smaller in caliber, bends outwards and then inwards and backwards, thus forming a loop just behind the oral sucker. The reduced tube is continued posteriorly as an ascending limb, the latter being closely applied against the outer wall of the main collecting tube up to the middle level of the acetabulum and therefore difficult to detect. Behind that level

it separates from the main tube, and on reaching the level of the excretory bladder it gives off two sets of three capillaries with their corresponding flame cells. Then it describes a small loop, takes an anterior course (descending limb), and near the region of the oral sucker it breaks up into three capillaries with their corresponding excretory cells. The total number of flame cells is fifteen pairs, the distribution of which is shown in Plate 3, fig. 3. Due to the presence of the cystogenous glands it was not possible to trace accurately the capillary connections of the remaining six pairs (4th to 9th, inclusive) of these cells.

Liberation of cercaria from its host.—In two experimental infestations it was observed that snails began to yield cercariæ in from forty-two to fifty days after exposure to the miracidia. By placing some of these infested snails singly with small amounts of tap water in small glass vials, it was further observed that the escape of the cercariæ from their hosts occurs during the day, between 11 in the morning and 5 o'clock in the afternoon. The greatest number emerged between 1 and 3 o'clock. This finding agrees with the observations of Cort (1922) and Rees (1931), who determined that in the case of other echinostome cercariæ their emergence from their snail hosts also occurs during the daytime only. It further agrees with the explanation given by Rees, who ascribes the phenomenon to an accelerated rate of development of the larvæ during the day on account of the gradual rise of temperature because of the following observation. In the Philippines during the cool days of December, it was often noticed that the appearance of the cercariæ was much delayed when vials containing infested snails were left standing near an open window. In another lot of vials placed near an incubator or in a warm chamber, the emergence of the larvæ was much accelerated.

By removing and counting the larvæ escaping into the water at one- to two-hour intervals, estimates were made of the total number of cercariæ a single infested snail could produce each day. Counts made from six snails and extended for five days gave a total daily yield of from 58 to 194 cercariæ per snail, with an average of 119. One snail had a nearly uniform daily yield of from 190 to 194, while in another one the number ranged from 72 to 186. These figures most probably are due to differences in the number of mature daughter rediæ harbored by a particular mollusk, but they are significant in demonstrating the potentially large number of infective metacercariæ that a single snail can produce daily.

Method of locomotion and duration of free existence.—The cercaria is an active swimmer, its attitude when thus engaged is similar to that of *Cercaria* "Z," as described by Rees (1931). The body is bent ventrad so that it is concavo-convex; the tail continues along the ventral surface and then bends back again just behind its root. The result is that the dorsal surface of the body is foremost with the tail lashing on the ventral surface. When the larva comes in contact with a substratum, its method of locomotion is by creeping; that is, by the alternate attachment of its suckers to the surface.

The duration of the free existence of the cercaria is brief, its active life lasting not more than ten hours under laboratory conditions. After that time it sinks to the bottom and is soon dead. Recently emerged larvæ, placed at 4 to 5 o'clock in the afternoon in small, cotton-plugged test tubes filled with water and stood under the surface of the water in a balanced aquarium, were invariably found dead the following morning.

ENCYSTED METACERCARIA

Formation.—Like other echinostome cercariæ, the cercaria of *Euparyphium ilocanum* has to undergo a process of encystment and be transformed into a metacercaria before it is able to infect a suitable vertebrate host. It is obviously for these reasons and in order to look for a favorable spot for encystment that it escapes from its redia after reaching a certain stage in its development. It has never been found to encyst inside its redia, as is the case with some of the other echinostome cercariæ. By keeping it under close observation in different kinds of environment, it was determined that it is also unable to encyst either in water or on aquatic plants and that it can only do so in the body of a second intermediate host, which is a snail. If a free-swimming cercaria comes in contact with any exposed portion of the body of such a host, it attaches itself tenaciously by means of its suckers and by the use of the same organs it works its way into the pulmonary chamber, presumably through the respiratory opening.

The process of encystment consists essentially in the shedding around its body surface of the secretion of the cystogenous glands, which on hardening forms a protective envelop for the inclosed larva or metacercaria. Simultaneously with the formation of the cyst, the tail becomes gradually detached from the body. Encystment can apparently take place on any portion of the inner wall of the mantle cavity, but the sites of predilection are the soft tissues around the pericardium and at the hinder por-

tion of the digestive tract, the wall of the pulmonary sac in those snails possessing such a structure, and the surface of the liver.

Although, as stated in an earlier section of this paper, the cercaria is able to encyst in many kinds of fresh-water snails, it was noted repeatedly in experiments conducted for the purpose of determining the second intermediary host of the parasite that the larva is especially attracted by the large ampullarid *Pila luzonica* (Plate 4, fig. 4). When large numbers of free-swimming cercariæ were placed in small beakers of water with this snail, they disappeared completely due to encystment after thirty to forty minutes; with the other kinds of snails, after one and one-half to three or more hours. This may be taken as an indication that *Pila luzonica* is probably the normal second intermediate host of the parasite. As far as the transmission of the fluke to human beings is concerned, it is believed that such is very probably the case; for, as will be shown later, this particular snail is often eaten raw by many people in the endemic places.

With reference to the presence of cysts in *Gyraulus prashadi*, which also serves as a primary intermediate host, some explanation seems necessary. The fact that cysts were found only in those individuals of this snail which harbored rediæ and cercariæ is taken as an indication that the origin of these cysts was not from cercariæ that had already escaped into the water. What probably happens is that, due to certain obstacles, the exit of some of the cercariæ, from either their rediæ or the mantle cavity of the snail, is delayed to such an extent that when the proper time for encystment arrives the cercariæ still find themselves within the body of their first intermediate host.

Description.—The cyst (Plate 1, fig. 6) is a globular or slightly oval structure, inside which the metacercaria lies bent on itself. It is double-walled; the outer wall is thin and membranous, measuring 120 to 133 by 108.2 to 129 microns; the inner cyst wall is 2 to 3 microns thick and measures 116 to 129 by 105 to 125 microns. The space between the two walls seems to be filled with a fluid substance. In view of the presence of only one variety of cystogenous glands in the cercaria, it is believed that only the inner cyst wall is produced by the parasite, the outer wall being probably of host origin.

Resistance and longevity of cysts.—The cysts are quite frail, the outer cyst wall being readily broken even by the slightest mechanical pressure. The inner cyst wall is more resistant and less easily penetrated by a chemical agent, like a 4 per cent solu-

tion of acetic acid. The inclosed metacercaria is quickly destroyed by drying and by exposure to the rays of the sun. In the body of a snail the cysts can remain alive and infective for about a week after their formation; after that time the inclosed metacercariæ are usually dead or, if they are still alive, their viability is very much reduced. A cyst containing a dead metacercaria is recognized by its greater transparency due to the disintegration of the larva and, of course, by the absence of any movement on the part of the metacercaria.

THE ADULT

The adult specimens collected from experimental animals represent the parasite in different stages of its growth. Although they exhibit wide variations in the dimensions, not only of the body but also of the various internal organs, they possess the general characteristics of *Euparyphium ilocanum* (Plate 4, fig. 1) and are provided, as pointed out in an earlier paper (Tubangui, 1931), with fifty-one collar spines.

In view of the available descriptions by different writers, it will not be necessary to take up in detail the morphology of the adult worm. The smallest gravid specimens, 2.5 millimeters in length by 0.6 millimeter in maximum breadth, were collected from a white rat and were approximately one week old; the largest, 6.5 by 1.2 millimeters in size, were also from a laboratory rat and were about two weeks old. The cuticle is covered with numerous plaquelike spines arranged in alternating transverse rows; these spines extend on the ventral surface from the anterior end immediately behind the head collar to the posterior end of the second testis or slightly behind that level and on the dorsal surface from behind the collar to the level of the acetabulum. The kidney-shaped cephalic collar measures 0.11 to 0.15 by 0.22 to 0.34 millimeter and is armed with fifty-one spines arranged in two alternating rows uninterrupted dorsally (Plate 4, fig. 2). The five corner spines on each side of the collar are sometimes bunched together and measure 20.8 to 41.5 microns in length by 8.3 to 12.5 microns in maximum diameter; the lateral spines, of which there are thirteen to fourteen on each side, measure 25 to 45.7 by 10 to 12.5 microns; the dorsal spines, thirteen to fifteen in number, are 20.5 to 37.5 by 8.3 to 12.5 microns in size. The dimensions in millimeters of the different internal organs are as follows: Oral sucker 0.10 to 0.16 by 0.10 to 0.17; prepharynx 0.01 to 0.03 (length); pharynx 0.10 to 0.16 by 0.09 to 0.14; œsophagus 0.09 to 0.18 (length); aceta-

bulum 0.30 to 0.50 by 0.34 to 0.58; cirrus sac 0.26 to 0.54 by 0.13 to 0.27; ovary 0.10 to 0.32 by 0.13 to 0.37; shell gland 0.13 to 0.35 by 0.22 to 0.64; anterior testis 0.20 to 0.68 by 0.19 to 0.60; posterior testis 0.26 to 0.80 by 0.19 to 050. The ovary is usually transversely compressed; rarely it is globular. The testes in very young adults may possess smooth margins, but more often each organ is constricted either at the equator of its length or in several places so as to be divided more or less distinctly into lobes.

EPIDEMIOLOGICAL OBSERVATIONS

Infective agents.—Although no actual tests were made on man, it can be taken for granted from the results of the feeding experiments that human infestations with *Euparyphium ilocanum* are brought about by the consumption of raw or insufficiently cooked snails harboring the living encysted metacercariæ of the parasite. This conclusion is supported by epidemiological data gathered in Zambales and Ilocos Sur, where it was found that all those who were detected by fæcal examination to harbor the adult worm were addicted to the use of raw snails as food. Inquiries made in many places in the Philippines disclosed the fact that this habit exists almost exclusively in the northwestern provinces of Luzon; that is, among the Ilocanos. This explains the limited geographical distribution of the parasite in the human family. The favorite snail is the ampullarid *Pila luzonica* ("cuhol" in Tagalog and "bisocol" in Ilocano), in which, as already stated, the cercaria of the fluke readily encysts. It is said that many people, while at work in the fields or engaged in catching fish, often appease their hunger by eating this snail straight from the shell. In some houses it is consumed in much the same way, while in others it is served also uncooked but with salt or "bagoong" and with or without vinegar or lemon.

Another snail which is also sometimes used as food is the so-called crow snail, *Amphipeplea quadrasi* ("susung awak" in Pampango and "birabid" in Ilocano). This is said to be poisonous if not properly prepared, and for this reason many people prefer to cook it before serving it on the table. A few, however, eat it either raw or only half-cooked so that it may also be involved in the transmission of the parasite to human beings.

Foci of infection.—It was observed during the several trips made to the endemic places that, although both the primary

and secondary intermediate hosts of the parasite are widely distributed, there are certain isolated spots where the infection prevails and which serve as propagating centers. These foci are located near river beds where there are small but permanent collections of water for snails to live in throughout the year. A typical example is a place called Caarusipan in Barrio San Miguel, San Antonio, Zambales, where the incidence of infestation among the adult members of the population was found very high. The explanation for this is in the presence of two small fish ponds, each of which is near a house, in which the adult occupants harbor the adult parasite. Besides the mudfish (*Ophiocephalus striatus*), different kinds of snails, including *Pila luzonica* and several species of planorbids, breed in these ponds. In the absence of proper sanitary facilities and practices, one does not have to stretch the imagination to account for the high percentage of mollusks found infected with the larval stages of the fluke. It was learned that the people in Caarusipan and in the neighboring places derive their supply of snails from these two ponds.

PROPHYLAXIS

With its mode of development known, as shown graphically in text fig. 1, the prevention of the parasite appears simple and consists in breaking any one of the links of the life cycle. This may be accomplished by adopting one or several of the measures that are generally recommended in the control of other trematode

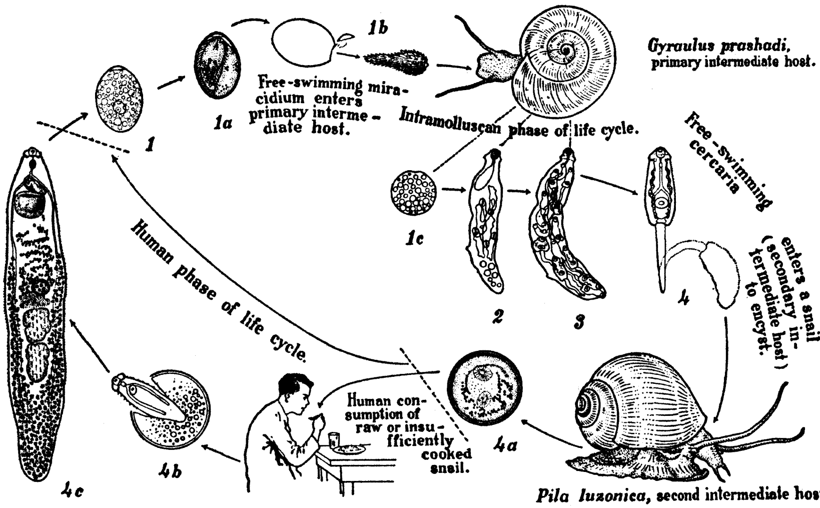

FIG. 1. Diagram of the life cycle of Euparyphium ilocanum (Garrison, 1908).

infestations; such as, the proper disposal of fæcal material, the destruction of intermediate hosts by drainage or by poisoning, the treatment on a large scale of infected individuals, the destruction of reservoir hosts, etc. Some of these measures, however, are either difficult and expensive to apply or prejudicial to the economic interests of the people. What to us appears to be the easiest and most practical mode of approach is to educate the people to dispose of their fæces properly in order to prevent the infestations of snails and, above all, to avoid the use of raw or insufficiently cooked snails as food. In these simple measures we are confident the people will gladly coöperate, if they are told of the dangers that they can avoid.

ACKNOWLEDGMENTS

In conclusion we wish to record our gratitude to those who directly or indirectly have helped us in this work. We wish especially to thank Dr. William H. Brown, director of the Bureau of Science, who supported the undertaking and enabled us to bring it to an early finish. We are indebted to Dr. L. A. Faustino, of the Bureau of Science, for the identification of snail hosts. To Mr. Simplicio Garcia, formerly of the Bureau of Science, we wish to express our appreciation for his technical assistance. To Messrs. Enrique Magsaysay and Pedro Madarang our thanks are due for various courtesies extended to us during our survey work in San Antonio, Zambales.

SUMMARY

The life history of the intestinal fluke *Euparyphium ilocanum* (Garrison) has been determined and found to conform to the echinostome type of development.

The following stages of the life cycle are described: Egg, miracidium, miracidium-sporocyst, mother redia, daughter redia, cercaria, encysted metacercaria, and adult.

Two molluscan intermediate hosts are involved; namely, a primary intermediate host, in which the parthenitæ develop, and a secondary intermediate host, in which the cercaria encysts and is transformed into an infective metacercaria.

The snail found capable of playing the rôle of primary intermediate host is a small fresh-water planorbid, *Gyraulus prashadi* Faustino.

Apparently any of the common Philippine fresh-water snails, including the primary intermediate host itself, is acceptable as a secondary intermediate host.

279193——13

The eggs, which are in the one-cell stage in freshly passed stools, attain the miracidial stage in water at a room temperature of 26° to 31°C. after six to fifteen or more days. They hatch three to five days after the formation of the miracidium.

The cercariæ begin to escape from experimentally infected snails forty-two to fifty days after the exposure of the latter to miracidia.

The adult stage was obtained by feeding encysted metacercariæ derived from experimentally and naturally infected secondary intermediate hosts (mostly *Pila luzonica*) to clean laboratory white rats, a cat, and two monkeys. Feeding experiments with young pigeons and a pup yielded negative results.

The adult fluke as well as its cercarial and metacercarial stages are characterized by the presence of fifty-one collar spines arranged in two alternating rows uninterrupted dorsally.

From the results of the feeding experiments and the nature of the epidemiological data collected, it is concluded that human infestations are brought about by the consumption of raw or insufficiently cooked snails harboring the living encysted metacercaria of the parasite.

The limited geographical distribution of the fluke is explained by the observation that the habit of using raw snails as food is practiced almost exclusively by some of the people in northwestern Luzon.

The snail most commonly eaten is the ampullarid *Pila luzonica;* hence, this mollusk is considered as the most important secondary intermediate host in the transmission of the parasite to human beings.

The infection originates from certain foci near river beds, where there are more or less permanent collections of water for snails to live in throughout the year.

The prophylactic measures recommended consist in educating the people to dispose of their fæces properly and to avoid the use of raw or insufficiently cooked snails as food.

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ILLUSTRATIONS

[Drawings by A. Gonzales]

ABBREVIATIONS USED

ac, acetabulum.
av, ascending excretory vessel.
cc, cephalic collar.
cg, cystogenous gland.
cs, cirrus sac.
cv, caudal excretory vessel.
dv, descending excretory vessel.
eb, excretory bladder.
ep, excretory pore.
fc, flame cell.
ga, genital anlage.
gp, genital pore.
int, intestinal cæcum.
mt, main lateral excretory collecting tube.
oe, œsophagus.
ov, ovary.
ph, pharynx.
sg, shell gland.
t, testis.
ut, uterus.
vg, vitelline gland.

PLATE 1

FIG. 1. Outline of the egg shell with the operculum open.
2. Freshly passed egg, in one-cell stage, showing yolk balls and germinal area.
3. Early morula stage showing peripheral arrangement of almost empty yolk sacs.
4. Egg-miracidium, the latter fully developed.
5. Diagram of miracidium showing epidermal plates and lateral processes.
6. Encysted metacercaria.

PLATE 2

FIG. 1. Miracidium-sporocyst as seen in snail-juice culture.
2. Young mother redia with undifferentiated germ balls, ventral view.
3. Mature mother redia with young daughter rediæ, lateral view.
4. Mature daughter redia filled with cercariæ, lateral view.
5. Daughter redia showing excretory system, ventral view.

PLATE 3

FIG. 1. A mature cercaria after fixation in hot 10 per cent formalin solution showing relative lengths of body and tail, lateral view.
2. Mature cercaria, showing details of anatomy, ventral view.
3. Excretory system of cercaria, ventral view.

PLATE 4

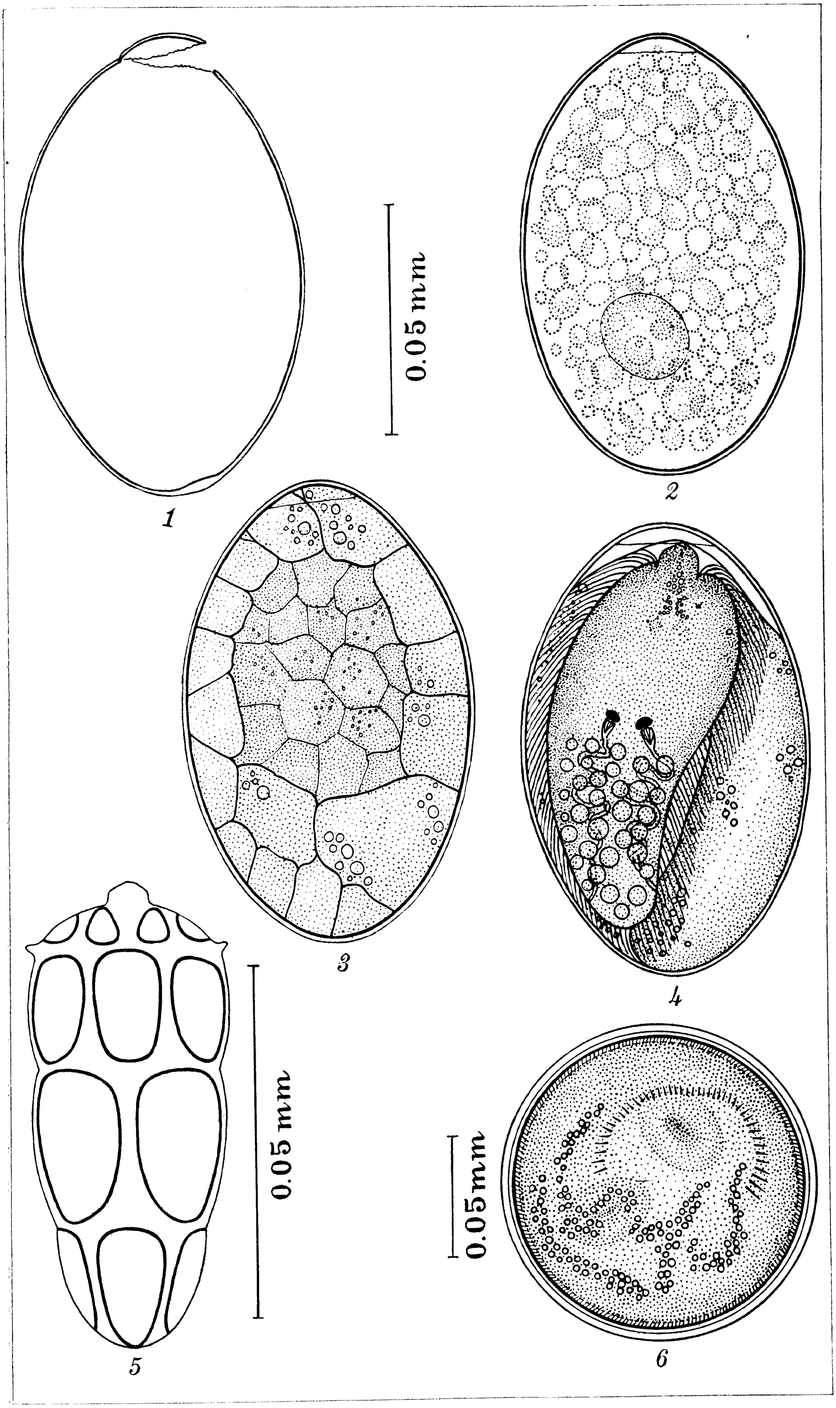
FIG. 1. Anatomy of adult worm, ventral view.
2. Cephalic collar showing number and arrangement of collar spines, ventral view.

FIG. 3. Shells of *Gyraulus prashadi* Faustino, the primary intermediate host of *Euparyphium ilocanum*, dorsal and ventral views.

4. Shell and operculum of *Pila luzonica*, one of the secondary intermediate hosts of the fluke concerned in the transmission of the parasite to human beings; ventral view.

TEXT FIGURE

FIG. 1. Diagram of the life cycle of *Euparyphium ilocanum*. *1*, Freshly passed egg; *1a*, egg with fully developed miracidium; *1b*, miracidium escaping from egg shell; *1c*, miracidium-sporocyst; *2*, mature mother redia; *3*, mature daughter redia; *4*, cercaria; *4a*, encysted metacercaria; *4b*, ruptured cyst liberating metacercaria; *4c*, adult.



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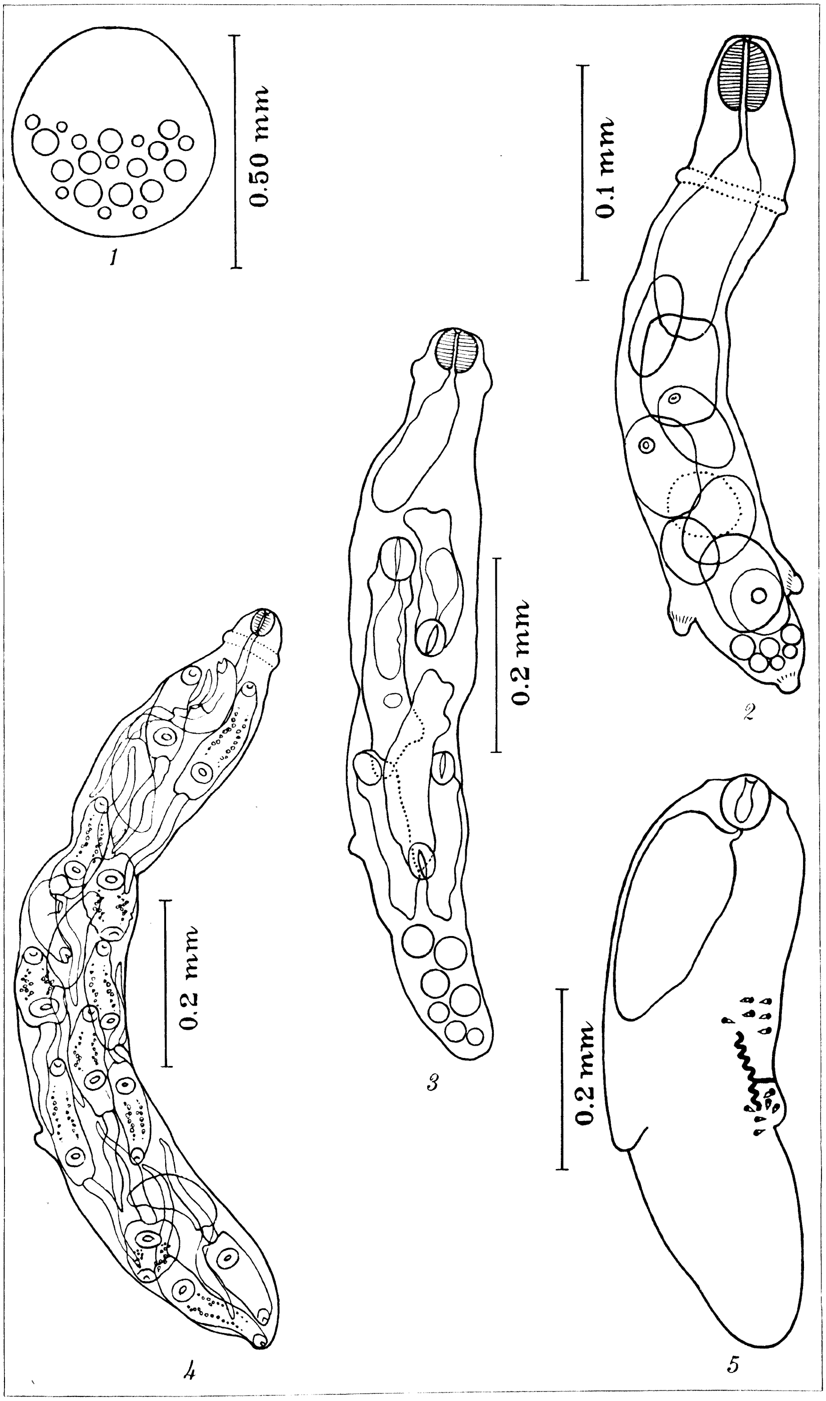

PLATE 2.

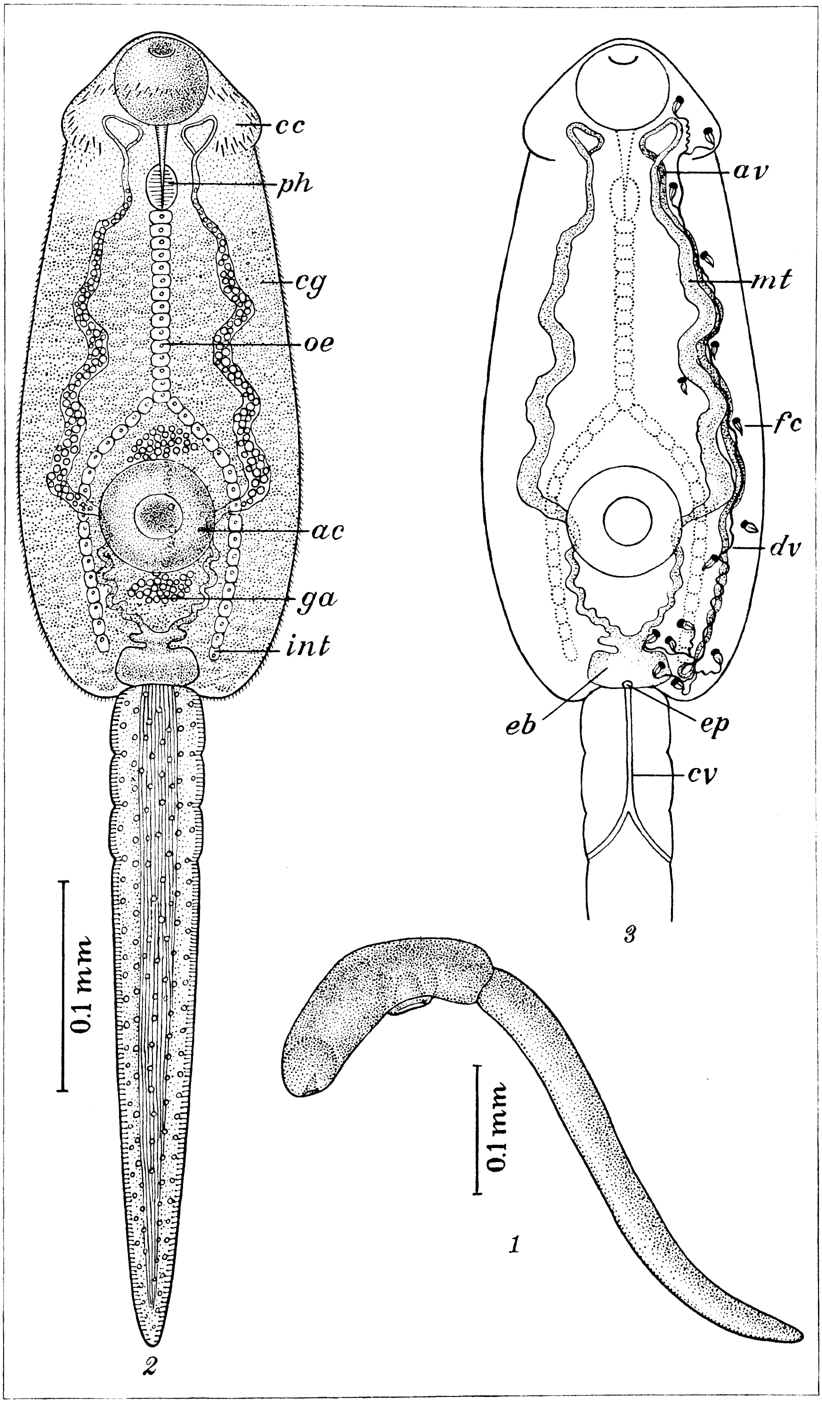

PLATE 3.

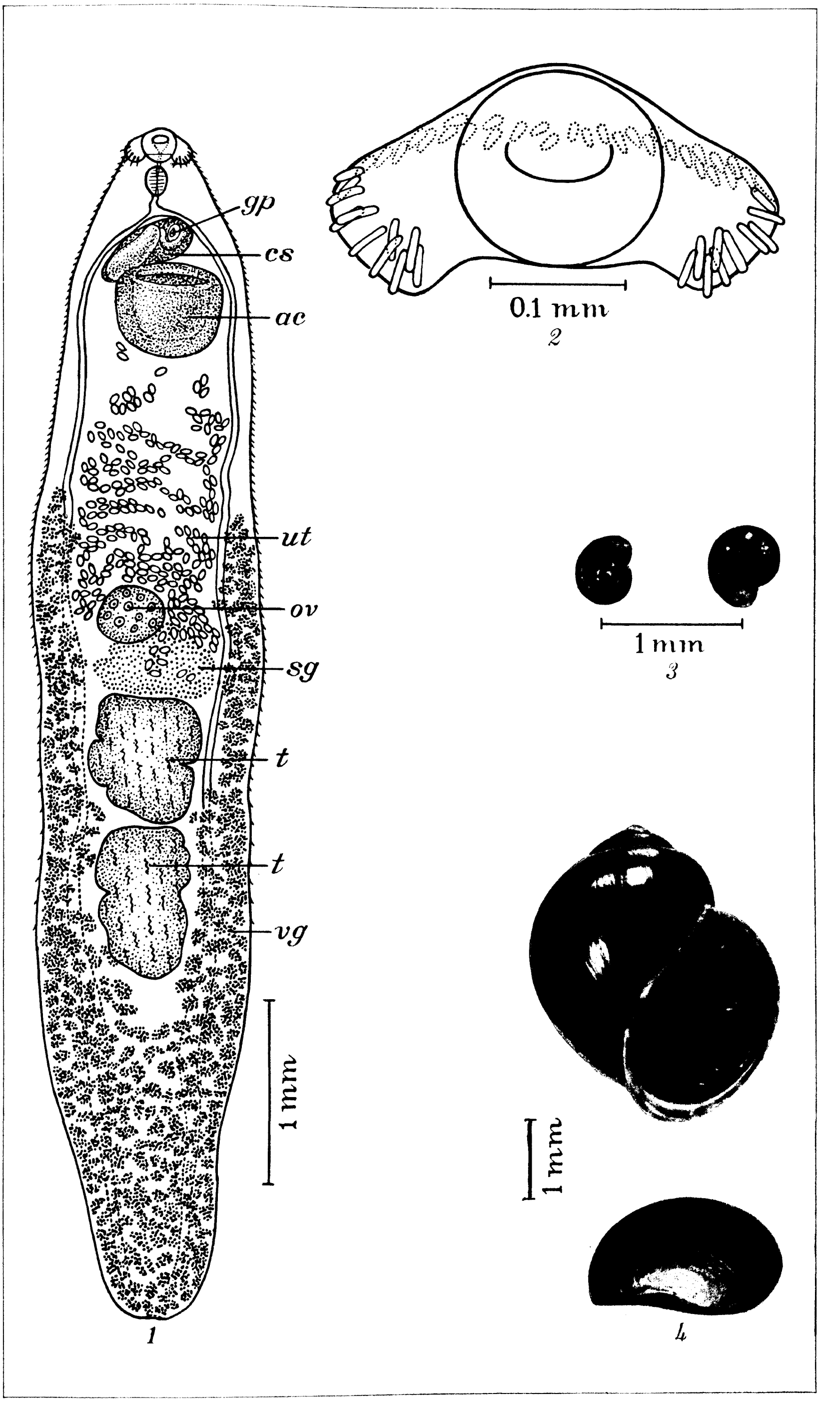

PLATE 4.

NEMATODES IN THE COLLECTION OF THE PHILIPPINE BUREAU OF SCIENCE, I: OXYUROIDEA

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THREE PLATES

The nematodes infesting Philippine vertebrates, with the exception of those found in domesticated animals, have received very little attention. In the available literature there are only two papers dealing with this group of the Philippine fauna, one by Wehr (1930) on four species of bird parasites and the other by Chu (1931) on two species collected from flying lemurs.

There is at our disposal a collection of roundworms which we intend to describe from time to time, the present constituting the first of the series and relating to three members of the superfamily Oxyuroidea. The large majority of the parasites were obtained from birds by Mr. A. Duyag, to whom we wish to express our appreciation.

SUBULURA CYNOMOLGI sp. nov. Plate 1, figs. 1 to 6.

This seems to be a common parasite of the Philippine macaque, being represented in the collection by several bottles each containing numerous specimens collected from individual hosts that were brought to Manila from the neighboring provinces. According to Yorke and Maplestone (1926), Stiles and Hassall (1929), Cameron (1930), and Lee (1930), the genus *Subulura* Molin includes seven members that have been reported from primates in various parts of the world. The Philippine parasite differs from these known forms in several important characters. It appears to be most closely allied to *S. malayensis* Lee, 1930, a parasite of two species of monkeys in the Malay Archipelago, from which it may be distinguished by its larger size, proportionately shorter œsophagus, smaller gubernaculum, and longer and subequal spicules. They both possess ten pairs of caudal papillæ, but the arrangement of these is different in the two forms. In *S. malayensis* there are three pairs of preanal papillæ, one adanal and six postanal; while in *S. cynomolgi*

three pairs are also preanal, but two pairs are adanal and only five postanal.

Specific diagnosis.—Subulura: Body tapers towards both extremities, ending posteriorly in a pointed tail. Posterior end of male curved, that of female almost straight. Cuticle finely striated transversely. Mouth opening small, terminal, bounded by three simple lips. On each side of the mouth is a row of three roundish papillæ, arranged in such a way that each lip is provided with two of them. The mouth leads into a prominent cavity with a chitinous wall and measuring 0.08 to 0.10 by 0.06 to 0.08 millimeter. Arising from the floor of this cavity are three triangular teeth with their pointed ends directed anteriorly. Œsophagus long with a characteristic posterior bulb provided with a valvular apparatus. Cervical papillæ absent.

Male: Length 18 to 27.7, maximum diameter 0.36 to 0.48 millimeters. Œsophagus 2.15 to 2.37 millimeters in total length by 0.26 to 0.32 millimeter across the bulb. Nerve ring 0.36 to 0.40 and excretory pore 0.60 millimeter, respectively, from anterior end. Genital sucker oval, 0.22 to 0.24 millimeter long, supplied with radiating muscles. The sucker and the cloacal opening are 0.96 and 0.28 to 0.33 millimeter, respectively, from the tip of the tail. There are ten pairs of caudal papillæ, three of which are preanal, two adanal, and five postanal. Of these papillæ only the first adanal pair and the third postanal pair are decidedly lateral, the rest being more or less ventrally located. The two filiform spicules are subequal, the right spicule being 2.16 to 2.22 and the left 2.24 to 2.53 millimeters in length; both are 0.040 to 0.056 millimeter wide at their proximal ends and 0.02 millimeter near their distal extremities. The gubernaculum is triangular, measuring 0.14 to 0.16 by 0.058 to 0.060 millimeter.

Female: Length 22 to 30 millimeters, maximum diameter 0.48 to 0.66. Œsophagus 2.30 to 3.13 millimeters in length by 0.28 to 0.36 millimeter across the bulb. The nerve ring is 0.40 to 0.60 and the excretory pore 0.64 to 0.66 millimeter, from the anterior end. Vulva fairly prominent, located in front of the middle of the body length or 9 to 11.5 millimeters from the anterior end. Anus 1.15 to 1.50 millimeters from tip of tail. The ova found in the distal portions of the two opposed uteri are oval, thin-shelled, embryonated, 64.5 to 77.4 by 38.7 to 47.3 microns in size.

Host.—Philippine monkey (*Cynomolgus philippinensis*).

Location.—Large intestine.

Localities.—Novaliches, Rizal Province (type locality), and Los Baños, Laguna Province, Luzon.

Type specimens.—Philippine Bureau of Science parasitological collection, No. 402.

SPIRONOURA DUYAGI sp. nov. Plate 2, figs. 1 to 5.

The genus *Spironoura* Leidy, 1856, according to Yorke and Maplestone, includes fifteen species of roundworms parasitic in tortoises, snakes, and fishes. To these should be added *S. onama* described by Karve (1927) from a Burmese tortoise (*Testudo emys*). By referring to the key of Baylis and Daubney (1922) to the species infesting tortoises, which is based on the number of caudal papillæ and on the presence or absence of preanal suckerlike organs in the male, it will be seen that the Philippine parasite needs only be compared with *S. siamense* (Baylis, 1920), *S. affine* [=*Falcaustra chapini* (Boulenger, 1923)], and *S. onama*. It differs from the latter two species in being decidedly larger in dimensions, not only of the body but also of the different organs, in possessing more than one genital sucker, and in the arrangement of the caudal papillæ in the male. It is distinguished from *S. siamense* by its generally smaller size, the presence of two or three genital suckers in the male, the arrangement of the male caudal papillæ, and the absence of a pair of caudal papillæ in the female. With reference to the male genital suckerlike organs it is seen that *S. duyagi* is intermediate between *S. affine* and *S. onama* on the one hand and *S. siamense* on the other.

Specific diagnosis.—*Spironoura:* Body tapering towards both extremities, rounded anteriorly, conspicuously pointed posteriorly; posterior end of male curved. Cuticle transversely striated. Head not separated from the rest of the body by a distinct neck. Mouth opening triangular, bounded by three simple lips, one dorsal and two submedian, each provided with two stalks of papillæ, each of which branches into an outer and an inner process. The mouth leads into a short buccal cavity supported by a cuticular ring and measuring 0.03 to 0.04 by 0.08 to 0.09 millimeter, and then to a pharynx 0.05 to 0.07 by 0.09 to 0.12 millimeter in size. The œsophagus is divisible into three parts, according to its varying degree of chitinization, the middle of which is dark brown because it is the most heavily chitinized. The œsophagus ends in an hourglass-shaped bulb containing a valvular apparatus. This principal bulb is preceded

and separated by a constriction from a secondary bulb, the two constituting the posterior portion of the œsophagus.

Male: Length 11.5 to 13, maximum diameter 0.40 to 0.72 millimeters. Œsophagus 1.75 to 1.82 millimeters in total length; its anterior portion measures 0.69 to 0.71 by 0.13, the middle portion 0.50 to 0.56 by 0.15, and the posterior portion 0.43 to 0.47 by 0.26 to 0.27 millimeter. Nerve ring, cervical papillæ, and excretory pore 0.32 to 0.34, 0.86 to 0.88, and 1.24 to 1.26 millimeters, respectively, from the anterior end. Caudal alæ absent. Musculature of posterior end well developed. There is a series of two or three (generally two) genital sucker-like organs on the ventral surface, the most posterior of which is about 1 millimeter from the cloacal opening. These suckers are oval and about 0.22 millimeter long. The tail is short, sharply pointed, curved, and 0.47 to 0.50 millimeter long. There is a single median papilla immediately in front of the cloacal opening and ten paired ones, of which five pairs are preanal and five pairs postanal. Of the paired papillæ, the second and third postanal pairs are more or less lateral, and the rest are decidedly ventral in position. The two spicules are equal, sickle-shaped, 0.75 to 0.90 by 0.060 to 0.063 millimeter in size. They possess transversely striated walls and are inclosed in membranous sheaths up to near their pointed extremities. The poorly chitinized gubernaculum is triangular with the apex pointing towards the cloacal opening and measures 0.16 to 0.19 by 0.09 to 0.10 millimeter.

Female: Length 13 to 15, maximum diameter 0.78 to 1.0 millimeters. Œsophagus 1.82 to 1.88 millimeters in total length; its anterior portion measures 0.69 to 0.71 by 0.15, its middle portion 0.56 to 0.61 by 0.15 to 0.17, and its posterior portion 0.43 to 0.47 by 0.26 to 0.30 millimeter. The distances from the anterior end to the nerve ring, cervical papillæ, and excretory pore are 0.30 to 0.31, 0.94 to 0.96, and 1.18 to 1.26 millimeters, respectively. The vulva is 4.5 to 5.6 and the anus 0.88 to 0.97 millimeters from the tip of the tail. Caudal papillæ absent. The eggs found in the distal portions of the two opposed uteri are oval, non-embryonated, 130 to 150 by 100 to 110 microns in size.

Host.—*Cyclemis amboinensis* (Daudin).

Location.—Cæcum.

Locality.—Novaliches, Rizal Province, Luzon.

Type specimens.—Philippine Bureau of Science parasitological collection, No. 418.

CISSOPHYLLUS LEYTENSIS sp. nov. Plate 3, figs. 1 to 5.

According to Yorke and Maplestone, the genus *Cissophyllus* Railliet and Henry, 1912, is represented by *C. laverani,* the genotype, and possibly by two other species, all of which are parasites of turtles. The present form was collected on two occasions from the large intestine of the herbivorous lizard, *Hydrosaurus pustulosus* (Eschscholtz). It is smaller than *C. laverani* and its œsophagus is shorter. The spicules and gubernaculum of the male are also much smaller and the genital papillæ number nine to ten pairs, of which five to six pairs are preanal and only four pairs postanal. In the genotype there are eleven pairs of these papillæ, of which six pairs are preanal and five pairs postanal.

Specific diagnosis.—Cissophyllus: Body elongate, stout, slightly tapering towards both extremities. The posterior end is curved ventrally in the male, nearly straight in the female; in both sexes it terminates abruptly in a short tail, that of the male being more conical. The cuticle is transversely striated. The mouth is elongate dorsoventrally and is guarded by three lips. The dorsal lip is smaller but is provided with a powerful three-jointed structure ending distally in a three-lobed tooth. The subventral lips are larger, each reënforced externally by a chitinous framework of four compartments and armed with a series of closely set, pointed, lamellar processes directed towards the median line. The mouth is surrounded by six papillæ, which in position and appearance are similar to those of the type species of the genus. It leads to a buccal cavity bounded by a chitinous wall and measuring 0.13 to 0.14 by 0.12 to 0.13 millimeter. The œsophagus is long and divided into three parts according to its varying degree of chitinization. The anterior part appears poorly chitinized and is light in color; the middle part is heavily chitinized and is dark brown; the posterior part, which ends in a distinct bulb with a valvular apparatus, is intermediate in color and in degree of chitinization between the first two. Cervical papillæ are generally lacking; in rare cases a minute unpaired papilla is seen on one side in front of the excretory pore.

Male: Length 13 to 21.7, maximum diameter 0.98 to 1.50 millimeters. Œsophagus 1.93 to 2.20 millimeters in total length;

its anterior part is 0.66 to 0.74 millimeter long by 0.12 to 0.16 millimeter wide, its middle part 0.64 to 0.80 by 0.16 to 0.17, and its posterior part 0.67 to 0.73 by 0.30 to 0.40. The nerve ring and excretory pore are 0.48 to 0.52 and 1.3 to 1.5 millimeters, respectively, from the anterior end.

A definite genital sucker is absent, but the musculature of the posterior end is well developed. There are nine to ten pairs of sessile caudal papillæ, of which five to six pairs are preanal and ventral, one pair adanal and lateral, and three pairs postanal and lateral. The last three pairs of preanal papillæ are more or less bunched together, while the first pair is sometimes absent. The two spicules are similar, slightly bent in lateral view and measuring 0.56 to 0.90 by 0.05 to 0.09 millimeter. The gubernaculum is poorly chitinized, triangular, the apex directed posteriorly and ending in two short processes; it measures 0.14 to 0.20 by 0.04 to 0.06 millimeter. The cloacal opening is 0.21 to 0.30 millimeter from the tip of the tail.

Female: Length 17 to 23.5, maximum diameter 1.10 to 1.60 millimeters. Total length of œsophagus 1.96 to 2.30 millimeters, anterior portion 0.64 to 0.72 by 0.12 to 0.14, middle portion 0.63 to 0.84 by 0.16 to 0.17, posterior portion 0.66 to 0.78 by 0.30 to 0.42. Nerve ring and excretory pore 0.56 to 0.60 and 1.60 to 1.85 millimeters, respectively, from anterior end. Vulva behind middle of body; it is 4 to 6.7 millimeters and the anus 0.26 to 0.50 millimeter from the tip of the tail. The two uteri are opposed; the vagina is fairly long and is directed anteriorly from the vulva. Eggs found in the distal portions of the uteri and in the vagina are thin-shelled, non-embryonated, and measure 108 to 129 by 63.5 to 72.8 microns.

Host.—*Hydrosaurus pustulosus* (Eschscholtz).

Location.—Large intestine.

Locality.—Palo, Leyte (type locality), and Novaliches, Rizal Province. Luzon.

Type specimens.—Philippine Bureau of Science parasitological collection, No. 425.

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ILLUSTRATIONS

[Drawings by A. Gonzales]

ABBREVIATIONS USED

an, anal opening.
ap, accessory piece (gubernaculum).
co, cloacal opening.
cp, cervical papilla.
cr, cuticular ring.
dt, dorsal tooth.
ep, excretory pore.
gp, genital papilla.
gs, genital sucker.
ll, lamellar processes.
mo, mouth.
mp, mouth papilla.
mpi, inner mouth papilla.
mpo, outer mouth papilla.
nr, nerve ring.
oe, œsophagus.
ph, pharynx.
sp, spicule.

PLATE 1. SUBULURA CYNOMOLGI SP. NOV.

FIG. 1. Anterior end of male, ventral view.
2. Head, seen from its anterior aspect.
3. Posterior end of male, lateral view.
4. Posterior end of male, ventral view.
5. Gubernaculum, ventral view.
6. Posterior end of female, lateral view.

PLATE 2. SPIRONOURA DUYAGI SP. NOV.

FIG. 1. Anterior end of female, ventral view.
2. Head, seen from its anterior aspect.
3. Posterior end of female, lateral view.
4. Posterior end of male, lateral view.
5. Spicules and gubernaculum, ventral view.

PLATE 3. CISSOPHYLLUS LEYTENSIS SP. NOV.

FIG. 1. Anterior end of female, lateral view.
2. Head, seen from its anterior aspect.
3. Posterior end of female, lateral view.
4. Posterior end of male, lateral view.
5. Spicules and gubernaculum, ventral view.

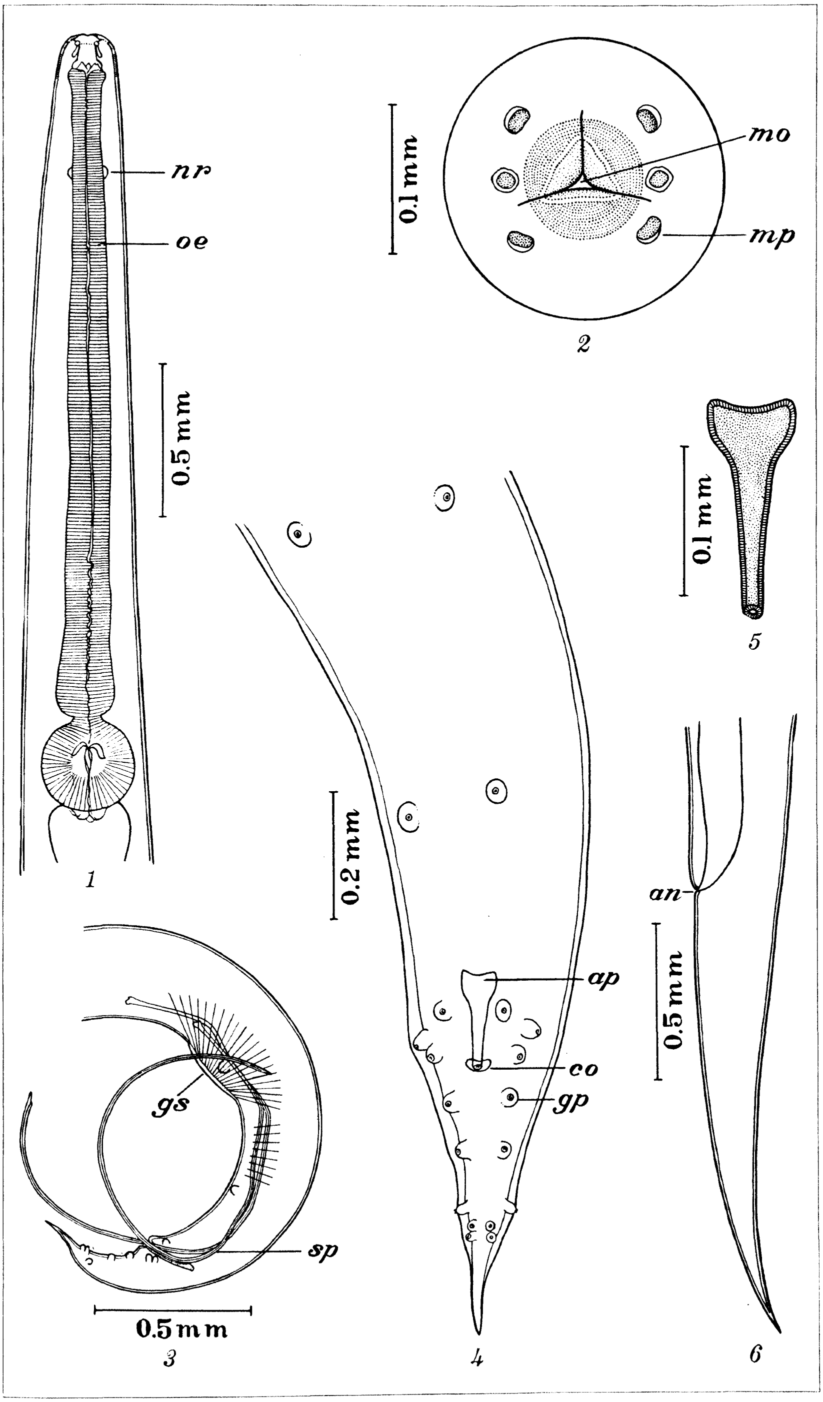
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PLATE 1.

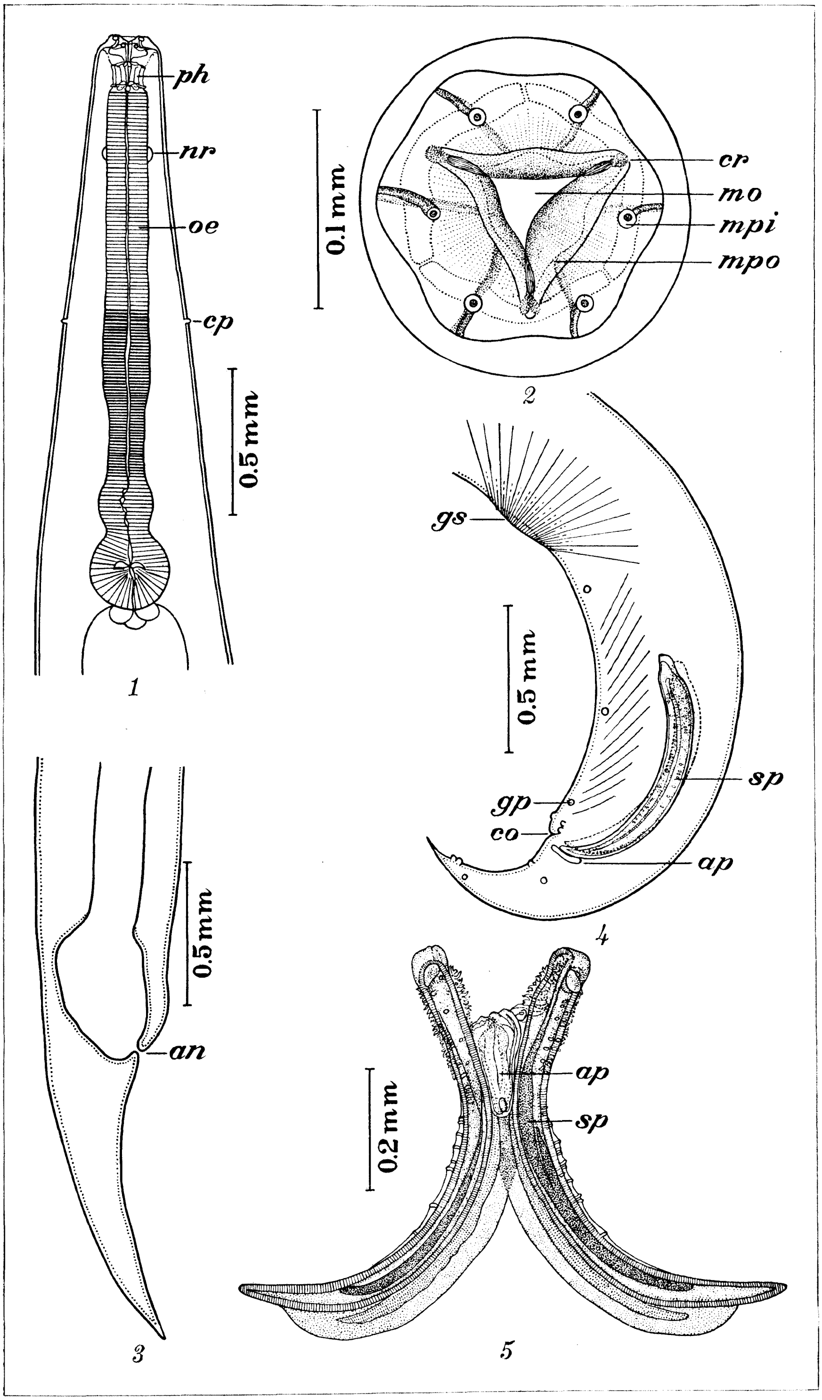
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PLATE 2.

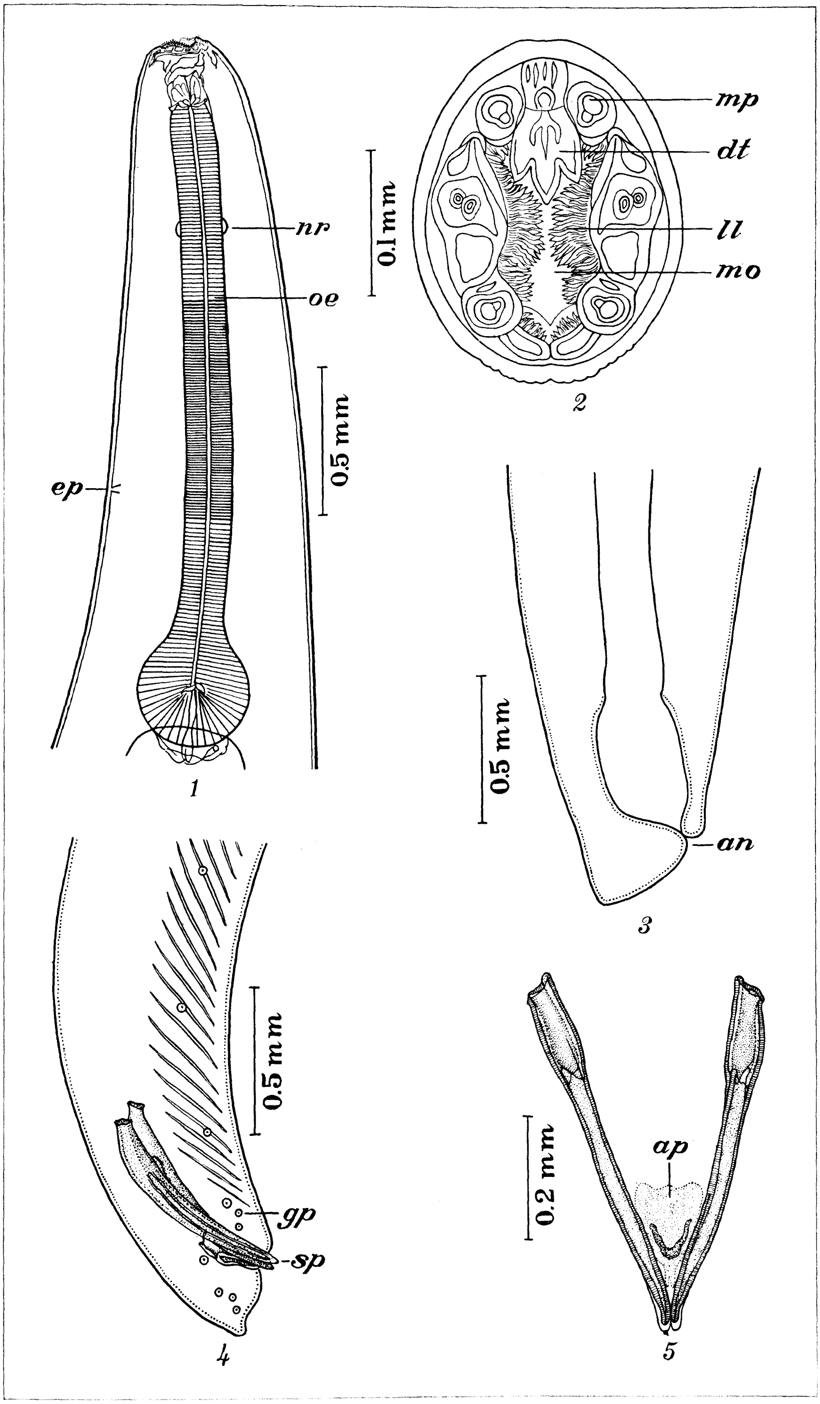

PLATE 3.

GRAM-POSITIVE FORMS OF MYCOBACTERIUM LEPRÆ FROM LEPROTIC LESIONS BACTERIOLOGICALLY NEGATIVE FOR ACID-FAST ORGANISMS: A PRELIMINARY REPORT

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Much(1) in 1907 devised a number of staining methods in order to determine if the presence of the tubercle bacillus can be demonstrated in such tuberculous lesions as *perlsucht* in cattle and cold abscess in man where it was often impossible to find acid-fast bacilli in smears and yet by culture and pathogenicity experiments the organisms were shown to be present. He brought forth convincing evidence that under certain conditions the bacilli of tuberculosis may be present in the tissues in the form of nonacid-fast granules.

His most successful method was to stain the smear with aniline gentian violet or methyl violet B. N. at 37° C. for twenty-four to forty-eight hours, then to treat it with Lugol's solution, and decolorize it by a mixture of absolute alcohol and clove oil. The decolorization was also accomplished by using successively nitric acid 5 per cent (1 minute), hydrochloric acid 3 per cent (10 seconds), and finally equal parts of acetone and absolute alcohol. In films from miliary tubercles of a calf that had been inoculated with virulent bovine bacilli, he failed to find bacilli when the films were stained by the Ziehl-Neelsen method, but in preparations stained by his own method he found many fine rods, often accompanied by small, rounded granules arranged singly, in pairs, or in short chains resembling beaded bacilli.

Examining the tubercles daily, he found the fine rods and the granules in smears three days after the inoculation, whereas no organism was demonstrated by the Ziehl-Neelsen method till after the sixth day.

Pieces of lung tissue positive by Much's method and showing no acid-fast organism gave rise to fatal generalized tuberculosis in eight weeks when injected subcutaneously in guinea pigs.

Acid-fast bacilli were found in the tissues of the dead animals. Similar results were obtained with tuberculous materials from various sources.

Much concluded that—

1. There is a granular nonacid-fast form of the tubercle bacillus which can be demonstrated by his method.
2. This granular form may be the only stainable form of the tubercle bacillus present in tuberculous organs.
3. The granular form may be accompanied by fine rods which likewise are nonacid-fast.
4. The granular forms are virulent.
5. There are transition forms between the gram-positive granules, the fine gram-positive rods, and the acid-fast rods and granules.

In the magazine containing the report of Much's work is another article on the same subject by Michaëlides(2) who, using modifications of the Gram-Nicolle as well as of the Loeffler-Giemsa stains, also found nonacid-fast forms of the tubercle bacillus.

Using either Much's or Michaëlides's modifications of the Gram stain, the granules in tuberculosis are seen to be definite, clean cut, round, or oval bodies about 0.5 micron in diameter. Ordinarily, they are stained deep purple, almost black, although there may be a tinge of blue or yellow. They may lie singly or, more frequently, in rows of two to five, or in clusters. There can usually be seen a faint brownish, yellowish, or bluish band connecting the granules, suggesting the body of a bacillus in or on which the granules lie. Unless this band is present, they should not be accepted as true Much's granules.

METHODS

Not being aware of any previous work on the subject, we attempted to demonstrate the presence of nonacid-fast forms of *Mycobacterium lepræ* in leprotic lesions of the skin which were persistently negative for the acid-fast organisms.

After smears were prepared from the cutaneous lesions in the ordinary manner and fixed by heat, Much's modification of the Gram stain was followed, step by step. The stained preparations proved very unsatisfactory at first, and the detection of any Gram-positive organisms corresponding to Much's rods and granules in tuberculosis was rendered almost hopeless, not only on account of the presence of precipitated stains, micrococci,

yeast bodies, and dirt from the surface of the skin, but particularly because of the numerous keratine granules from the granular layer of the epidermis.

In order to minimize this difficulty, smears from lesions showing plenty of acid-fast bacilli were studied first. After fixation with heat, the smears were given a preliminary treatment with solutions of sodium bicarbonate and antiformin in dilutions similar to those employed in preparing sputum for acid-fast examination, after which they were stained according to Much's method. Although this process was rather complicated and many if not most of the organisms were washed away, the preparation became clearer and the chance for error was considerably reduced.

After many trials, the following method was adopted for a time in our routine work:

1. Fix the smear with heat. It is preferable to set the slide aside for four to six hours before staining. If stained too soon, much of the tissue may be washed away in steps 2 and 3.
2. Cover smear with 2 per cent sodium carbonate solution. Duration depends on the thickness of the smear, and is usually five to thirty minutes. Discard the excess.
3. Cover with antiformin and let it stand for five to ten minutes. The antiformin must be fresh. Discard the antiformin and wash. Fix gently with heat again.
4. Cover with one of the following stains: (*a*) Saturated alcoholic solution of methyl violet B. N., 1 part; 2 per cent phenol, 10 parts. (*b*) Saturated alcoholic solution of gentian violet, 1 part; 1 per cent phenol, 9 parts. (*c*) Saturated alcoholic solution of gentian violet, 1 part; saturated aniline water, 3 parts.
5. Discard the excess and add Lugol's solution; let stand for one minute. Wash quickly. Do not blot, as this will likely add dirt and precipitated stain to the preparation.
6. Treat with 5 per cent acid for one minute. Discard the excess; do not wash.
7. Apply 3 per cent hydrochloric acid (HCl) for twenty seconds. Discard the excess.
8. Decolorize by dropping acetone and absolute alcohol (equal parts) on the smear until no more stain is removed.
9. Wash with distilled water.
10. Without drying, counterstain for three to five minutes with Bismark brown.

Although this method has the advantage of being rapid, cheap, and fairly acceptable for routine purposes, much better preparations can be obtained by the use of staining jars in which the slides are placed edgewise. Some recommend that in step 4 the preparation be stained with either aniline gentian violet or methyl violet B. N. for twenty-four to forty-eight hours at 37° C., but in our experience, room temperature is sufficient. This is much more satisfactory than steaming the slide. A little practice is necessary to keep the material in the smear from being completely washed away.

By any of the foregoing methods, *M. lepræ* stains either as a solid rod or more frequently, as a granular bacillus. The granules are definite, cleancut, rounded or oval, with a diameter of about from 0.3 to 0.6 micron, and are deep purple or almost black. There are usually from two to five granules to each organism. Connecting the granules is a brownish or yellowish band suggesting the body of a bacillus in which the granules are embedded.

When smears stained according to the Ziehl-Neelsen method were compared with smears stained by these methods from a leproma known to be rich in acid-fast bacilli, we noted that considerably fewer organisms were demonstrable with the modified Gram stain. The globi were also fewer. This was ascribed to the loss of many bacilli in the preliminary treatment with the sodium carbonate solution and antiformin.

For this important reason, in the latter part of the work, when we had become better acquainted with the appearance of the Gram-positive forms, steps 2 and 3 were omitted and the slide with the fixed smear was stained directly.

Suspecting that both acid-fast and nonacid-fast forms may be present in the same lesion, we have tried various combinations of acid-fast and Gram stains on the same smears. Using Fontes's method, the preparation was stained first with carbol fuchsin, decolorized with acid alcohol, and followed by the ordinary Gram method, counterstaining, however, with Bismark brown. The acid-fast bacilli showed as red or pinkish rods with violet granules, while those which did not fully possess acid-fast properties showed as zigzag violet lines. In our experience, however, many of the acid-fast bacilli are so tinged with violet that it was very difficult to distinguish them from the supposed partially or wholly nonacid-fast bacilli.

We also tried to stain the smear first with carbol fuchsin, then decolorized it with acid, followed by Much's method. All the bacilli took only the Gram stain.

When Much's method was used first, however, and immediately followed by the Ziehl-Neelsen stain, using Bismark brown as a counterstain, it was observed that a large percentage retained the Gram stain. In a few bacilli, we have seen one or two granules which retained the Gram stain while the rest of the granules in the same organisms showed acid-fastness. We took these to be transition forms.

Partially acid-fast and nonacid-fast bacilli may also be demonstrated in ordinary preparations stained according to the Ziehl-Neelsen method. When the staining is carefully done, it will be seen in some smears, particularly those showing many fragmented or granular acid-fast organisms, that some of the bacilli, or granules within the bacilli, are decolorized and take up the counterstain.

In order to avoid possible errors, we have considered in the present report only those Gram-positive nonacid-fast forms in which the granules were arranged in rows—in other words, the bacillary forms. In order to be accepted as true Much's granules the granules had to be connected by the faint brownish or yellowish band. If the single or bunched granules had been included, we should have been able to report a larger number of positives, especially among early cases of leprosy with "closed" lesions. Towards the end of the investigations covered by this report, we became quite confident of being able to distinguish many of these isolated or bunched Much's granules from the other granules in many of our preparations. However, as has been stated, unless the bacillary forms were also present, such cases were reported as negative.

It must be admitted that even with the best technic, the bacilli are always harder to differentiate by the Much method than by the Ziehl-Neelsen stain. Therefore, it needs more than ordinary care to stain by the former method to secure satisfactory results.

In the first place, the slide must be meticulously clean and free from grease spots. The smear must contain as little serum and blood as possible. Oftentimes the success of the method depends on the decolorization; if this is underdone, there will appear numerous extraneous granules, while if it

is carried too far, the granules will not show their typical deep purple or blue-black color.

FINDINGS

Table 1 gives the classification of the patients examined and the percentage found positive with the Ziehl-Neelsen and the Much stains.

TABLE 1.—*Comparative results of the Ziehl-Neelsen and the Much stains.*

Classification of patients.	Examined.	Positive with Z-N stain.		Positive with Much stain.	
		Cases.	Per cent.	Cases.	Per cent.
"Pre-quiescent" (Qt??)	33	15	45.45	19	57.57
"Probationary quiescent" (Qt?)	42	11	28.57	20	47.62
"Candidates for parole"	45	8	17.77	23	51.11
"Quiescents under parole"	48	8	16.66	32	66.66
"Closed" cases of leprosy	78	0	0.00	26	33.33

In order that the significance of these findings may be understood, it is necessary to outline here briefly the regulations of the Bureau of Health governing the examinations which have to be undergone by every candidate for "parole."

As soon as a previously "open" case is declared to be clinically inactive and bacteriologically negative by his treating physician, he is presented before a local examining committee who examine him at least ten times during a period of one year, which has to be spent in segregation. The first four examinations have to be successfully undergone during the first three months, which period is known as the "pre-quiescent period" (abbreviated Qt??). During the succeeding nine months, known as the "probationary period of quiescence" (abbreviated Qt?), at least four examinations have to be made by the local examining committee. In addition, the candidate must be examined at least twice by a National Disposal Committee sent from Manila by the central office of the Bureau of Health. Any candidate found to be bacteriologically positive or to show definite clinical signs of activity in any of these examinations is dropped from the list and has to start from the beginning when he becomes bacteriologically or clinically "negative" again. Eight smears, on an average, are taken at each examination, so that from seventy to eighty smears from each patient have to be found negative consecutively before he can become a can-

didate for parole. At the Eversley Childs Treatment Station, these examinations were made by four different bacteriologists at various stages of the "pre-quiescent" and "probationary quiescent" periods. In spite of these precautions some are always found "positive" at the tenth or last examination before parole.

"Quiescent cases under parole" are required to be examined once every three months for a period of two years, and thereafter, once every six months for a period of four years. As a matter of fact, however, only a small proportion of the cases are examined regularly after parole.

The last visit of the National Disposal Committee to the Eversley Child Treatment Station was made during the second and third weeks of January, 1933. The smears for the Much stain were taken from the same patients examined by the Committee throughout a period extending from about one month previous to and another month after this last visit of the committee.

Eleven of the thirty-three "pre-quiescent" cases were positive and ten were negative to both Ziehl-Neelsen and Much stains. Eight were negative for acid-fast but positive for nonacid-fast bacilli. In four other cases, acid-fast forms were found to be present but were missed by the Much method.

Among the forty-two "probationary quiescents," eleven were found positive by the committee, of whom seven were also positive and three were negative with the Much stain. In one case, acid-fasts were found by the committee in smears from sites not examined with the Much stain. Of the twenty found positive with the Much method, seven were positive also for acid-fasts as already stated, and thirteen, or 30.95 per cent, did not show any organism with the Ziehl-Neelsen stain. Attention is called to the fact that only in a few cases were acid-fast bacilli demonstrable that had been missed by Much's method. The acid-fast forms in such smears were very few.

Eight, or 17.77 per cent, of the forty-five candidates for parole were found positive by the committee and dropped from the list. Twenty-three of the same forty-five patients, or 51.11 per cent, were found positive with the Gram stain. Of the eight cases found by the committee positive for acid-fast bacilli, four were found positive at sites not examined with the Much stain, while in two cases the latter stain failed to show the presence of the organisms demonstrated by the Ziehl-Neelsen method. Two other patients were positive to both stains. Of the twenty-three cases found positive with the Much stain, two were also

found positive for acid-fast bacilli by the committee as already mentioned, five were positive at sites not examined by the committee but examined by us with the Ziehl-Neelsen stain, and fifteen were found negative for acid-fast bacilli at the same sites both by the committee and by ourselves. Therefore, in fifteen of forty-five candidates for parole, or 33.3 per cent, it was possible to show the presence of nonacid-fast bacilli in smears from sites which were found by the committee and by ourselves to be negative for acid-fast forms.

Only forty-eight "quiescent cases under parole" could be examined. Fourteen among them were negative, and six were positive to both the Ziehl-Neelsen and the Much stains. Twenty-six were positive only with the Much method and negative for acid-fast, while but two showed the latter forms of *M. lepræ,* which could not be demonstrated with the Much stain.

It will be noted in Table 1 that while the proportion of those found positive for acid-fasts gradually decreased from the "prequiescents" down to the "quiescents under parole," the proportion found positive with Much's stain does not show such relation.

"Closed" cases of leprosy are patients that show definite clinical manifestations of leprosy, but have never been found bacteriologically positive on routine examinations for acid-fast organisms. Fifty-two of these cases were found negative and twenty-six positive with the Much stain. Of course none of them was found positive for acid-fast forms, otherwise they would have been declared "open" cases. We failed to demonstrate nonacid-fast bacilli in the depigmented macules exhibiting an atrophied appearance of the skin or that showed evidences of returning to normal pigmentation. All macules found harboring the nonacid-fast forms showed clinical evidences of activity such as raised borders or a pink flush, either at the borders, or centrally, or all over the lesion. In not a few of these "closed" cases of leprosy, the nonacid-fast forms were present in fairly large numbers.

Many smears from a number of "leper suspects" and from persons with acute and chronic skin diseases have been examined also with Much's granule stain. Two of these were found positive. One was diagnosed as sarcoid (?) and the other had what appeared to be a chronic eczema on the front of the legs in which leprosy was also suspected.

It must be stated that as a rule only a few nonacid-fast bacilli can be demonstrated by our present methods of staining.

Occasionally, however, such forms were found to be numerous in some of the incipient or "closed" cases of leprosy we have examined.

All of the patients examined with the Much stain will be followed carefully in the future so as to determine whether or not more will become "positive" for acid-fast forms among those found harboring nonacid-fast bacilli than among those who did not show such forms of *M. lepræ*.

REMARKS

While this investigation was in progress, an article by Hoffmann(3) became available to us, but it could not be translated till after the completion of the work covered by this preliminary report. Discussing the granular forms of the leprosy bacillus which he could demonstrate by both the Gram and the Ziehl stains, this investigator came to the conclusion that there were two types of these granules:

1. Degeneration forms showing variability in size and staining properties. These were seen chiefly in improving cases undergoing treatment.

2. Young granules which represented specially resistant forms necessary in the life cycle of the leprosy bacillus. These were found in newly developed lesions and in the blood serum of cases which had never been treated.

Klingmuller(4) showed that granules corresponding to the Much granules in tuberculosis could be demonstrated in leprosy by the careful use of the Ziehl-Neelsen stain and that these granules were capable of producing tissue reaction. Therefore, he concluded that they could not be considered merely as dead particles of the bacillus.

According to the same author, Marchoux was of the opinion that these granular forms were virulent and probably were more resistant forms than the typical bacilli. Paldrock was also quoted as stating that the granules represent reproductive elements.

It is to be noted that none of the workers cited has mentioned Gram-positive forms not demonstrable by the Ziehl-Neelsen stain. So far as we are aware, such forms were first described by Arning and Lweandowsky(5) in an important article which we have read after the completion of our present studies.

Restaining with the Much stain old sections which had been stained previously by either Lustgarten's or Ziehl's methods,

Arning and Lweandowsky obtained the following results in four cases:

First case.—Where formerly no bacilli could be demonstrated, isolated Gram-positive bacilli of the form and size of the leprosy bacillus were found with the Much stain.

Second case.—This case showed exceptionally numerous bacilli, many times the number originally found by Kuhne and Doutrelepont.

Third case.—In an early case of anæsthetic leprosy, Gram-positive forms were found in nerve sections which showed no bacilli by the Ziehl stain.

Fourth case.—In a section from the second case of tuberculoid leprosy reported by Jadassohn, the Much stain showed isolated characteristically formed bacilli within the tuberculoid infiltration. Jadassohn could demonstrate the presence of acid-fast bacilli only with difficulty in this particular case. Repeated and diligent search for acid-fast bacilli in this section by Arning and Lweandowsky gave negative results.

DISCUSSION

The finding of Gram-positive bacilli and granules in lesions of leprosy negative for acid-fasts suggests the possibility that *M. lepræ* may have a Gram-positive, nonacid-fast form or phase as is claimed by some authorities to be the case with *Bacillus tuberculosus.* That such forms are not merely degenerated leprosy bacilli was proved by the fact that they were also found in some of the bacteriologically negative macules of early or "closed" cases of leprosy.

The Gram-positive nonacid-fast forms were seen in smears from the skin in about one-third of the patients with leprotic lesions which were negative for acid-fast organisms, irrespective of whether or not such patients had received treatment, or whether they were "closed" cases or "quiescents" or "negatives" under parole. Therefore, our findings further suggest that the nonacid-fast forms are not affected by the chaulmoogra treatment.

Furthermore, these forms were not seen in the skin in the early anæsthetic, depigmented macule and seldom in pure neural leprosy. Aside from these exceptions, the Gram-positive nonacid-fast bacilli found in the skin did not seem to be limited to any particular stage of the disease.

Our studies with the Much stain in leprosy, correlated with simultaneous examinations with the ordinary Ziehl-Neelsen

stain, lead us to advance the theory that the progress of leprosy in the human body is probably somewhat as follows.

In the very early depigmented macule as well as in the early anæsthetic or maculo-anæsthetic type of leprosy, *M. lepræ* may be present in an as yet undemonstrable form which causes a distinct reaction in the tissues manifested by round-cell infiltration about the capillaries and arterioles. This unrecognized form has a distinct predilection for the cutaneous sensory nerves. It is possible that the organisms at this stage may be so minute as to be ultra-microscopic, or that no staining method has yet been perfected for their demonstration.

It is presumed that as the organisms gradually increase in size, the character of the tissue response also gradually changes until by the time the former are demonstrable by the Much's stain, the pathological picture of the lesion will have become the typical "tuberculoid" arrangement. From the nature of the tissue response, characterized by proliferation of endothelial-like cells, it may be presumed that the main defense of the body during this phase lies in the phagocytic activity of these and similar cells of the reticulo-endothelial system.

Later, due perhaps to the evolution of a necessary step in the life cycle of the invading organism, or to some change in the tissues of the host, the bacilli become acid-fast and the phagocytes are no longer able to dispose of them. Consequently, the bacilli proliferate within the now powerless phagocytic cells to form the well-known "lepra" cells. Using supravital staining methods, Koike(6) has shown these cells to be real histiocytes, following the classification of Sabin. The acid-fast bacilli may be phagocytosed also by the monocytes and polynuclear leucocytes of the blood and are thus distributed to other parts of the body.

When the acid-fast bacilli begin to appear, the lesions become thicker due to accumulation of masses of "lepra cells" and to fibrosis, and also become reddish in color due to new formation of minute blood vessels. New lesions appear at the sites of predilection such as the ear lobes, etc., due to dissemination of the bacilli by the monocytes and polynuclear leucocytes.

At this stage, a variable proportion of the bacilli remain non-acid-fast.

Walker and Sweeney(7) and Schöbl(8) have shown that the chaulmoogra and related oils and their derivatives possess an undoubted specific inhibitory effect in vitro against acid-fast

bacteria such as the tubercle bacillus. This property is not manifested against nonacid-fast microörganisms.

It is possible that chaulmoogra oil may also exercise a similar effect in vivo against the acid-fast stage of *M. lepræ* but not against the nonacid-fast forms. Therefore, the administration of this oil, particularly by the intracutaneous or "plancha," method, where the drug is brought into more or less direct contact with the acid-fast organisms, may bring about their destruction and elimination, together with improvement or disappearance of the infiltrations, nodules, and other manifestations of "activity" of the disease. The patient may then become a "quiescent" or "negative" case, without any manifestations of "activity" and be negative for acid-fasts, but still harbors Gram-positive nonacid-fast bacilli.

When such negatives suffer a "relapse," it simply means that some of the Gram-positive nonacid-fast bacilli have become acid-fast again.

We realize that this hypothesis explaining the development of the leprotic lesions is based on incomplete evidence at the present time. In fact, perhaps this difficult problem will not be solved definitely until after the disease has been successfully transmitted to laboratory animals.

The presence of a possible Gram-positive, nonacid-fast stage in the life cycle of *M. lepræ* is also suggested by the work of Vandremer, Sézary, and Brun,(9) who, using a filtrate of a leprous spleen which passed through a bougie L 3 and which remained apparently sterile in various media for nine months, were able subsequently to obtain Gram-staining pseudomeningococci which later developed into acid-fast bacilli.

CONCLUSIONS

1. By the use of Much's method, it is possible to demonstrate the presence of Gram-positive forms of *M. lepræ* in a considerable percentage of leprotic lesions which do not contain acid-fast bacilli.

2. That many of these nonacid-fast bacilli are not merely degenerated forms may be judged from the fact that they are numerous in many cases of so-called "closed" or "incipient" cases of leprosy which have not undergone treatment.

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A SIMPLE TECHNIC FOR ISOLATING SINGLE TRYPANOSOMES [1]

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FOUR PLATES

In 1914 Barber,(1) while working in the Bureau of Science, Manila, described a method for isolating single bacteria. His device consisted of a micropipette of such minute dimensions that the point was capable of drawing a single cell from a droplet of bacterial suspension placed in a glass chamber under the microscope. Following this discovery a number of micromanipulators have appeared in literature patterned after Barber's apparatus, among which those of Chambers,(2) Peterfi,(4) and Taylor(5) were the most important. With the rapid progress in cytological research, these appliances have been revised and modified to meet the purpose of each individual investigator. McLung(3) mentions other modifications of lesser importance. It is the concensus of opinion, however, that these devices are not only expensive but likewise complicated, and that it requires considerable training and experience to operate them successfully. In this paper the writer describes a method for isolating single trypanosomes in which, by reason of its simplicity and ease of manipulation, a technician can perform the entire operation after a few preliminary trials. Moreover, the materials that enter into its composition are inexpensive and readily obtainable in any laboratory. The following are the necessary materials of a complete set:

1 Mason jar, 8-ounce capacity, with rubber cork to fit.
1 Pyrex beaker, 250-cc capacity.
12 Oval hollow microscopic slides.
12 Plain microscopic slides.
1 Dispensing bottle, 30-cc capacity.
1 Capillary pipette with rubber nipple.

[1] Bureau of Animal Industry Technical Bulletin 1. From the Veterinary Research Laboratory, Bureau of Animal Industry, Pandacan, Manila. Received for publication June 22, 1933.

1 Test tube, 12 mm by 100 mm, agglutination type.
6 Capillary glass rods, knobbed at both ends, 2 mm by 100 mm.
2 Standard-size Petri dishes, 100 mm by 15 mm.
2 Rubber spatulas, 1 cm sq by 140 mm long, 7 mm by 14 mm.
1 Ordinary glass rod, 130 mm by 5 mm.
1 Surgical knife, bellied blade, 7 mm by 14 cm.
1 Pair cover-glass forceps or section lifter, 120 mm long.
Several pieces of sterilized gauze.
Plasma.
Serum.

These materials are illustrated on Plate 1.

PREPARATION OF MATERIALS

An 8-ounce Mason jar is fitted with a wide rubber cork pierced by a No. 16 brass wire and folded at the lower end to form a suspension hook for the cellophane strips (Plate 1, A). The cellophane cover of an ordinary cigarette box or cigar wrapper is soaked in tap water or alcohol and the outer varnish is removed by rubbing the paper between the fingers. This leaves a thin transparent skeleton paper that is smooth and glossy. The bare paper is washed twelve to twenty-four hours in a beaker of running water as in treating fixed tissues for histological examination. When dry, it is cut into convenient-size strips, usually $\frac{3}{4}$ inch by $2\frac{1}{4}$ inches, which are stored in a clean, wide-mouthed bottle properly stoppered. Sterile serum and plasma are prepared from rabbit blood by making an aseptic heart puncture and collecting the blood in tapered-bottom centrifuge tubes. To collect plasma a 1:1,000 heparin solution is used, 1 cc to every 10 cc of blood. The charged tubes are centrifuged for ten minutes at 1,800 revolutions per minute, and the plasma is transferred aseptically to a sterile tube. Sterile serum is prepared by slanting the charged tube and allowing the blood to clot overnight in the ice chest. The serum is then transferred into a bottle sterilized for the purpose (Plate 1, D). The entire ensemble of the equipment—glassware, knife, forceps, etc.—is sterilized in an autoclave at 15 pounds pressure for thirty minutes, except the cellophane paper which is sterilized in 85 per cent alcohol for twelve hours in the Mason jar for the purpose (Plate 1, A). The strips are transferred into distilled water in a sterile Petri dish (Plate 1, I) to wash off all traces of alcohol.[2]

[2] Repeated trials showed that cellophane paper in a jar of distilled water could be safely sterilized in the autoclave at 20 pounds steam pressure for half an hour.

Stock suspension of trypanosomes.—With a capillary pipette a drop of infected blood is placed in a hollow slide and a few drops of 30 per cent plasma are added. The mixture is drawn into the pipette and expelled gently several times. A small drop is placed on a slide and examined under the low power of the microscope. If there are found three or four organisms in the drop, the dilution is considered about right.

TECHNIC

A strip of cellophane paper previously sterilized in alcohol is immersed in a Petri dish of sterile distilled water to remove all traces of alcohol. With the cover-glass forceps, it is transferred to a plain sterile slide previously painted with serum fixative (Plate 2, fig. 1). To make a perfectly smooth mount a glass rod made for the purpose is rolled over it (Plate 2, fig. 2). The edges and the surface of the mounted cellophane are wiped perfectly dry with the sterile gauze. The knobbed end of the capillary glass rod is dipped in the suspension of the organisms and quickly touched upon the surface of the paper mount to deposit a tiny drop (Plate 3). This should be done rapidly in order to avoid evaporation. For this purpose, lay the slides carrying the paper mount and the stock suspension side by side in order to perform the act of depositing the drops as rapidly as possible to the point of making it almost instantaneous. After ten separate drops have been deposited 8 mm apart and in two rows, place the slide on the mechanical stage of a microscope and examine the drops under low magnification.[3] The moment that a drop is recognized to contain a single organism, raise the microscope tube, superimpose a tiny drop of 30 per cent plasma and proceed with the examination of the other drops. In this manner it is often possible to spot three or more drops containing single organisms. Each drop with a single organism is removed from the slide by cutting a small square through the paper mount around the drop with a sharp knife as illustrated in Plate 4, fig. 1. The point of the knife is inserted gently beneath the corners of the square to loosen the paper and with the coverglass forceps the section carrying the drop is lifted in toto as in Plate 4, fig. 2. Such preparations may be used for inoculating susceptible animals subcutaneously or intraperitoneally, or for cultivating the organisms in vitro. Needless to say, all used slides, papers, capillary glass rods, etc., should be immersed in the disinfecting solution at the completion of the work.

[3] Ocular 10 x, objective 10 mm, Zeiss microscope.

COMMENT

The advantage of the method just described over the more complicated apparatus of Barber, Chambers, Peterfi, and Taylor is obvious, in so far as the isolation of single trypanosomes is concerned. For such frail organisms as the hæmoflagellates this method of isolation is vastly superior to the pipette method because the delicate structures of the organisms are preserved in the drop, which is not disturbed in the least. Likewise, the transfer of one living organism to a culture medium or to a susceptible animal is absolutely assured without the risk of injuring, destroying, or losing it during the manipulation as might happen when micropipettes are used. Moreover, all the necessary materials for a complete outfit are readily procurable in an ordinary laboratory unit. Above all, are the ease and simplicity of the manipulation, which requires no extraordinary skill. Plasma solution is preferred to other diluents, not only because the trypanosomes survive in it for longer periods, but also because its viscosity is indispensable for making satisfactory minute drops that do not spread out on the paper. If it becomes necessary to perform the manipulations under aseptic conditions, the entire operation can be done under a fumigated glass hood or by the use of a glass chamber especially designed by the author and to be described in another paper.

SUMMARY

A simple technic for isolating single trypanosomes is described and its advantages over the micropipette apparatus are discussed.

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ILLUSTRATIONS

PLATE 1. ENSEMBLE OF EQUIPMENT

A, Mason jar containing 85 per cent alcohol for sterilizing the cellophane paper strips.
B, Beaker containing disinfecting solution 2.5 per cent lysol.
C, Hollow slide for making the dilutions of the parasites in suspension.
D, Sterile serum fixative.
E, Plain microscopic slides for mounting cellophane strips.
F, Capillary pipette for making dilutions.
G, Capillary glass rods with knobbed ends for stirring diluted suspension of protozoans and for depositing tiny drops on the mounted cellophane.
H, Sample of capillary glass rod.
I, Petri dish containing cellophane strips in sterile distilled water ready for use.
J, Flexible rubber spatula for smearing the serum fixative on the slides.
K, Ordinary glass rod, 130 mm by 5 mm, for rolling and mounting the cellophane strips.
L, Surgical knife for cutting sections of cellophane paper carrying the drops of the suspension.
M, Cover-slip forceps for lifting a small section of cellophane paper bearing the single protozoan.

PLATE 2

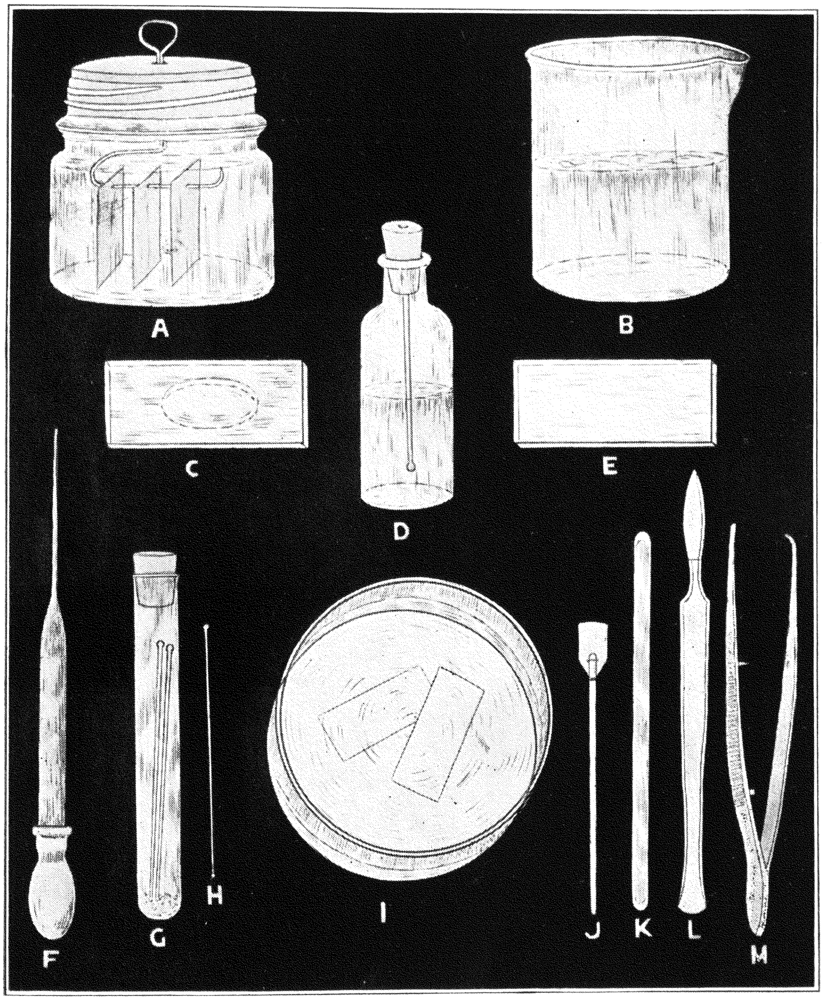
FIG. 1. Mounting the cellophane strips.
2. Rolling the mount to a smooth surface.

PLATE 3

Depositing the tiny drops of the suspension with the end of the capillary glass rod.

PLATE 4

FIG. 1. Cutting sections through the cellophane paper.
2. Lifting the section of cellophane paper bearing a drop which contains a single organism.



A, Mason jar containing 85 per cent alcohol for sterilizing the cellophane paper strips; B, beaker containing disinfecting solution 2.5 per cent lysol; C, hollow slide for making the dilutions of the parasites in suspension; D, sterile serum fixative; E, plain miscroscopic slides for mounting cellophane strips; F, capillary pipette for making dilutions; G, capillary glass rods with knobbed ends for stirring diluted suspension of protozoans and for depositing tiny drops on the mounted cellophane; H, sample of capillary glass rod; I, Petri dish containing cellophane strips in sterile distilled water ready for use; J, flexible rubber spatula for smearing the serum fixative on the slides; K, ordinary glass rod, 130 mm by 5 mm, for rolling and mounting the cellophane strips; L, surgical knife for cutting sections of cellophane paper carrying the drops of the suspension; M, cover-slip forceps for lifting a small section of cellophane paper bearing the single protozoan.

PLATE 1. ENSEMBLE OF EQUIPMENT.

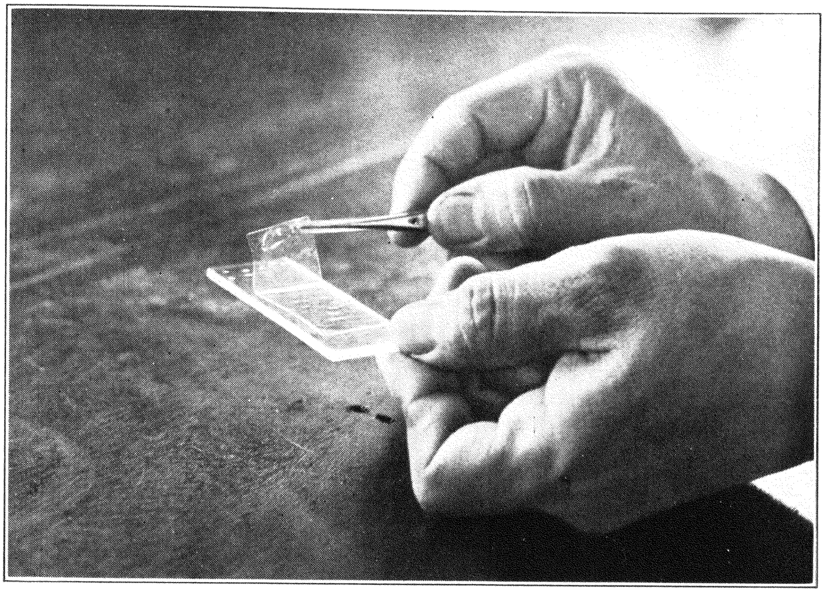


Fig. 1. Mounting the cellophane strips.

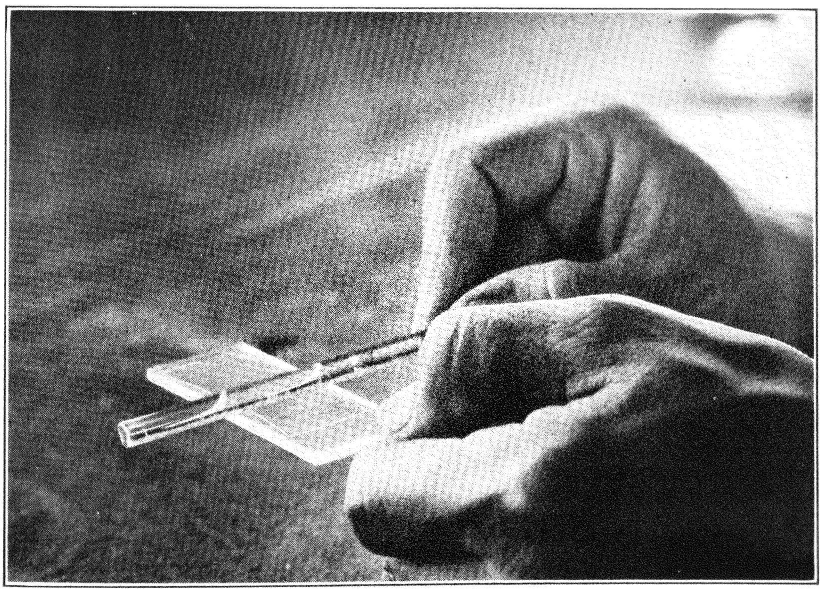
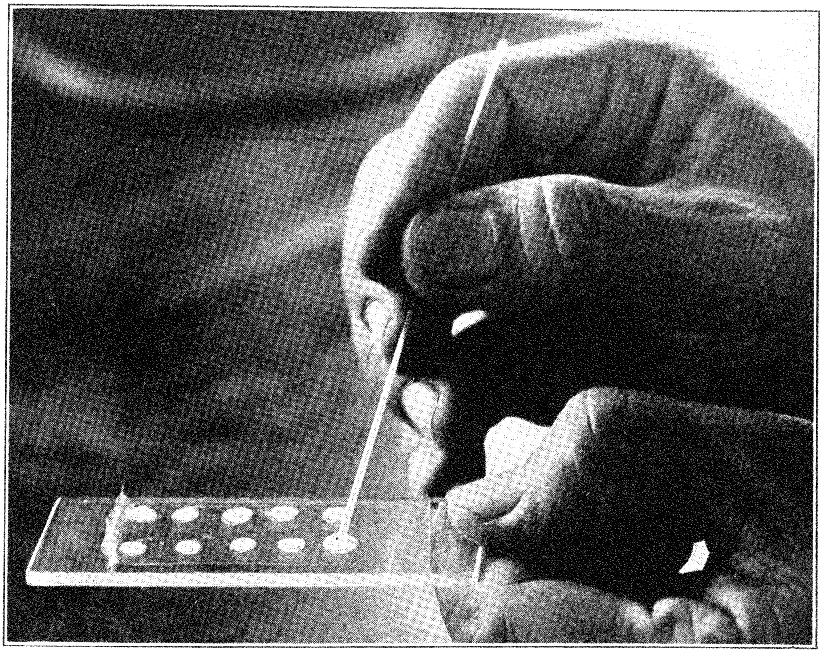


Fig. 2. Rolling the mount to a smooth surface.

PLATE 2.



Depositing the tiny drops of the suspension with the end of the capillary glass rod.

PLATE 3.

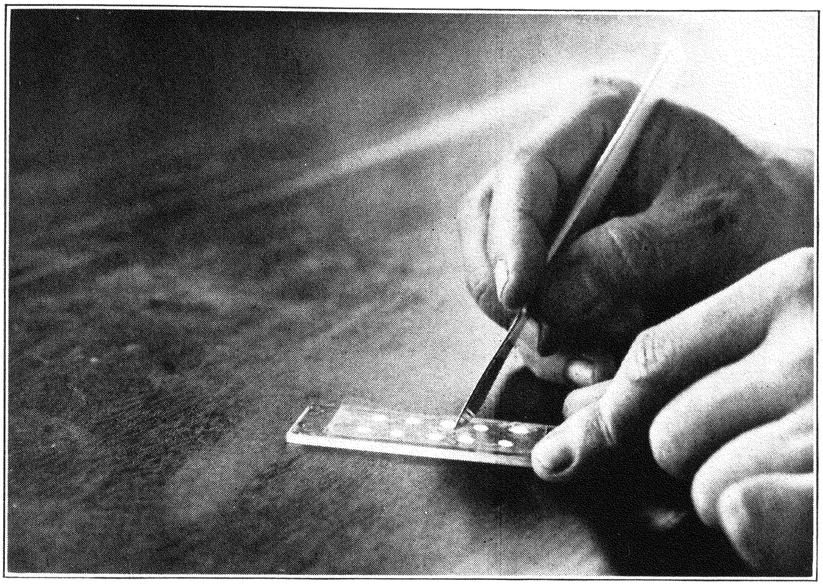


Fig. 1. Cutting sections through the cellophane paper.

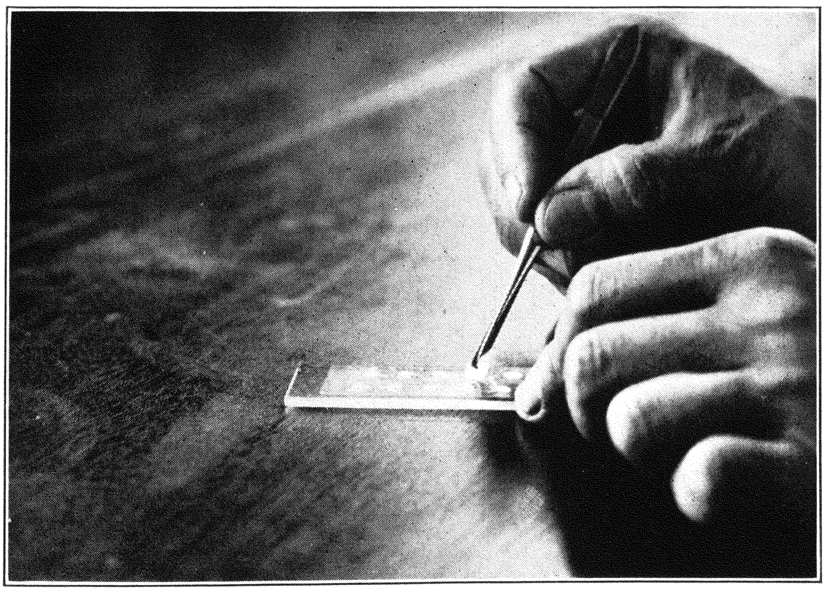


Fig. 2. Lifting the section of cellophane paper bearing a drop which contains a single organism.

PLATE 4.

THE ELECTRIC CHARGE OF RINDERPEST VIRUS [1]

By TEODULO TOPACIO

Of the Veterinary Research Laboratory, Bureau of Animal Industry Manila

ONE TEXT FIGURE

Not all filters are adapted to the filtration of virus diseases because it is now known that virus particles carry a certain electric charge when exposed to solutions of different hydrogen-ion concentrations. A case in point is the electric charge of foot-and-mouth disease. Olitzky and Boëz(4) found that on the acid of pH 8.0 the virus particles of foot-and-mouth disease carried a positive charge, while in higher alkalinity the charge was negative. Diatomaceous filters—such as, Berkefeld, Mandler, Chamberland, etc.—are generally negatively charged and, if the foot-and-mouth disease virus is to be passed, the concentration of the suspension must fall within pH 8.0 or its alkaline side to avoid being adsorbed or arrested in the candle. Olitzky and Koffman(5) have shown that the particles of tomato mosaic virus behave like mammalian viruses; that is, they carry a negative charge if they are suspended in liquids at pH 5.3 to 8.5; otherwise they carry a positive electric charge. These authors used a cataphoresis cell of the U-tube type and arrived at this conclusion by testing the virus particles recovered from the anode and cathode ends of the tube at varying pH ranges of the suspension under study. Bedson and Bland's(1) blotting-paper method is a much simpler set up and Findlay(3) determined the electric charge of fowl-pox virus and the agent of Rous sarcoma by this same means. He found that fowl-pox virus in suspensions with a pH 6.6 to 8.0 carried a negative charge, while Rous sarcoma also carried a negative charge at pH 5.6 to 8.0. The method is based on the principle that paper carries a negative electric charge and as such all particles in

[1] Bureau of Animal Industry Technical Bulletin 2. From the Veterinary Research Laboratory, Bureau of Animal Industry, Pandacan, Manila. Received for publication June 22, 1933.

suspension having the same charge at certain pH ranges should travel up the paper, and the virus should be present there without being arrested at the point of contact between the paper and the virus suspension. In the following experiments this method of determining electric charge was used.

METHOD AND MATERIALS

Virus.—Mesenteric glands were collected from a rinderpest animal killed at the height of the disease. After trimming the organs free of fat and capsules, a portion was minced with

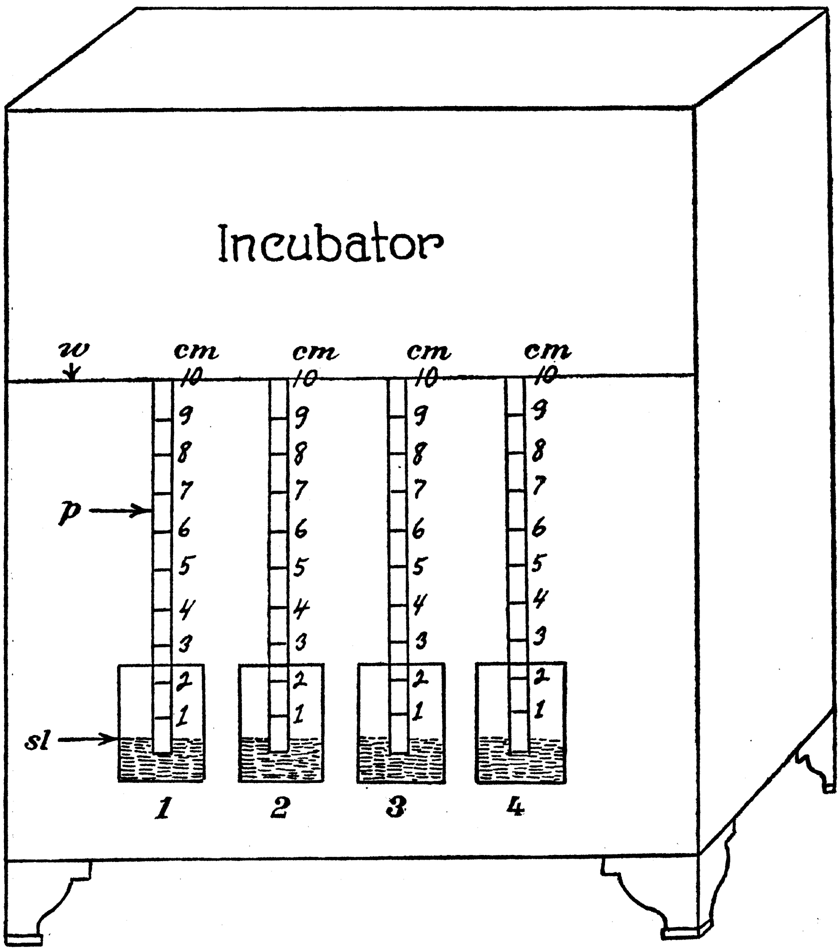


FIG. 1. Author's set up of the Bedson and Bland paper method for determining electric charge; *w*, wire line; *p*, blotting paper; *sl*, suspension level; *1*, *2*, *3*, and *4*, glass vials containing virus suspension in Sorensen's phosphate; *1*, at pH 5.2; *2*, at pH 6.2; *3*, at pH 7.2; *4*, at pH 8.2.

scissors and ground in a sterile mortar. A suspension was prepared in dilution of 1 to 10 with Sorensen's phosphate buffer at pH 5.2, 6.2, 7.2, and 8.2. Ten cubic centimeters of each suspension was placed in the corresponding vials and allowed to extract in a Frigidaire at 9° to 10° C. for one and one-half hours. These constituted the stock virus suspensions used in the experiments. For each experiment a fresh preparation of lymph gland virus was employed.

Paper strips.—White blotting paper was cut in strips 0.5 cm wide and 10 cm long. Each was graduated with lead pencil into 1-cm spaces up to the 9-cm mark, and then sterilized in a dry sterilizer on the day of the test. The charge of the paper was first tested with solutions of eosin and methylene blue to make certain that it carried a negative charge. The result was that the paper used in this experiment was negatively charged, since it arrested the absorption of methylene blue and permitted the eosin to travel through the entire strip.

The test.—A piece of wire was placed across the interior of an incubator heated to a temperature of from 28° to 30° C. The four wide-mouth vials containing the tissue suspensions at pH 5.2, 6.2, 7.2, and 8.2, respectively, were arranged in a straight row directly below the wire (fig. 1). One paper strip was fastened to the wire with a clip or else the top end of the paper was simply folded over the wire to hook it in a vertical position so that the lower end was immersed in the liquid 0.5 cm down. Each vial of the suspension was provided with a strip of paper in this fashion. It is absolutely essential that at no place must the paper touch the sides of the vial to avoid soiling it with the virus material. Absorption was allowed to proceed till the liquid had traveled upward to the 9-cm mark. The time required to accomplish this varied from thirty minutes to one hour.

Bedson and Bland recommend testing the virus from the 2- to the 6-cm mark, using in this case four 1-cm fragments. To abbreviate somewhat the number of tests for each suspension only two segments from centimeters 3 to 4 and 4 to 5 were used in these experiments. After the absorption time had elapsed the segments were macerated separately in 5 cc of corresponding phosphate buffer solutions. The entire suspension of each macerated segment was inoculated subcutaneously into a susceptible animal.

EXPERIMENT 1

Dalupiri carabaos[2] 1169 and 1168 were inoculated subcutaneously with 5 cc of the suspension from centimeters 3 to 4 and 4 to 5, respectively, in phosphate buffer pH 5.2; carabaos 1176 and 1170 received centimeters 3 to 4 and 4 to 5 in phosphate solution pH 6.2; carabaos 1173 and 1175 received centimeters 3 to 4 and 4 to 5 in phosphate solution pH 7.2; and carabaos 1180 and 1174 received centimeters 3 to 4 and 4 to 5 in phosphate solution at pH 8.2 in the order mentioned. To test the virulence of the stock suspensions, 2 cc of each was set aside and was injected separately into susceptible animals which served as controls. Fourteen days after the inoculation of the macerated paper segments, all animals that did not react then received 5 cc each of fresh virulent blood. Table 1 is a summary of results.

TABLE 1.—*Subcutaneous injection of carabaos with paper segments exposed to virus suspensions in Sorensen's phosphate of different pH values.*

Animal No.	pH of virus suspension.	Paper segments suspended in 5 cc Sorensen's solution. Centimeter—	First rise of temperature.	Result.
Carabao.	*pH.*			
1169	5.2	3 to 4	None	No infection.
1168	5.2	4 to 5	do	Do.
1176	6.2	3 to 4	5th day after injection	Killed for rinderpest vaccine.
1170	6.2	4 to 5	do	Do.
1173	7.2	3 to 4	6th day after injection	Do.
1175	7.2	4 to 5	do	Do.
1180	8.2	3 to 4	do	Do.
1174	8.2	4 to 5	7th day after injection	Do.
		CONTROLS		
Cattle.				
1829	5.2	2 cc virus suspension.	3d day after injection	Do.
1819	6.7	do	do	Do.
1972	7.2	do	do	Do.
1977	8.2	do	do	Do.

The result of this experiment was decisive, as might be judged from the reaction following the inoculation of susceptible

[2] A carabao is the native water buffalo.

animals. At pH 5.2 the virus failed entirely to migrate through centimeters 3 to 4 and 4 to 5; consequently, it failed to produce infection. From pH 6.2 to 8.2, however, all the segments injected into the animals produced typical rinderpest, showing that the virus made a perfect migration through the paper. This would indicate that at these pH ranges the virus carried a negative charge. The failure to infect at pH 5.2 would indicate that at this reaction the virus carried a positive charge which enabled the paper to arrest the migration of the virus particles. All animals inoculated with 2 cc of each stock suspension came down with rinderpest, showing that the virus was uniformly infective in the dilution employed.

EXPERIMENT 2

Susceptible native cattle 1678, 1679, 1690, 1910, 1902, 1903, 1113, and 1892 were each injected in the order given with emulsions of paper segments exposed to virus suspensions of varying pH ranges as in experiment 1. Fourteen days after the inoculations, all animals that did not react to the test received 5 cc each of fresh virulent blood. They developed typical rinderpest and were killed for rinderpest vaccine. Table 2 summarizes the result.

TABLE 2.—*Subcutaneous injection of cattle with paper segments exposed to virus suspensions in Sorensen's phosphate of different pH values.*

Animal No.	pH of virus suspension.	Paper segments suspended in 5 cc Sorensen's solution. Centimeter—	First rise of temperature.	Result.
1678	5.2	3 to 4	None	No infection.
1679	5.2	4 to 5	do	Do.
1690	6.2	3 to 4	do	Do.
1910	6.2	4 to 5	6th day after injection	Killed for rinderpest vaccine.
1902	7.2	3 to 4	do	Do.
1903	7.2	4 to 5	5th day after injection	Do.
1113	8.2	3 to 4	do	Do.
1892	8.2	4 to 5	do	Do.

Why segment 3 to 4 failed to infect cattle 1690 is not known. It might be inferred that there was not enough virus in the strip to cause infection in that particular animal. It is also possible that the animal had sufficient resistance to overcome

that dose. The other animals, however, developed rinderpest upon retest with 5 cc of virulent blood, with the exception of animal 1690. Otherwise, the result was an exact replica of the previous experiment on carabaos.

EXPERIMENT 3

This is a repetition of experiment 2 on cattle, using the same technic in every detail. Susceptible cattle 2059, 2066, 2061, 2060, 2063, 2062, 2058, and 2065 were injected in the order recorded in Table 3. Fourteen days after the inoculations all animals that failed to react received 5 cc each of virulent blood. They developed typical rinderpest and were killed for rinderpest vaccine.

TABLE 3.—*Subcutaneous injection of cattle with paper segments exposed to virus suspensions in Sorensen's phosphate of varying pH values.*

Animal No.	pH of virus suspension.	Paper segments suspended in 5 cc Sorensen's solution. Centimeter—	First rise of temperature.	Result.
2059	5.2	3 to 4	None	No infection.
2066	5.2	4 to 5	do	Do.
2061	6.2	3 to 4	do	Do.
2060	6.2	4 to 5	7th day after injection	Temperature reaction recovered.
2063	7.2	3 to 4	do	Killed for rinderpest vaccine.
2062	7.2	4 to 5	5th day after injection	Do.
2058	8.2	3 to 4	do	Do.
2065	8.2	4 to 5	None	No infection.

It is striking that in this experiment segment 3 to 4 exposed to virus suspension at pH 6.2 again failed to infect an animal as in experiment 2. While the individual resistance of the animal might be the principal factor in this particular case, yet it is likely that the behavior of the virus particles themselves in such solution held the greater share of responsibility. Segment 3 to 4 exposed to virus suspension of pH 8.2 also failed to infect. In this instance, however, it is possible that either a certain technical error may have crept in or, again, the particular animal inoculated might have resisted the dose; otherwise it would be difficult to explain why centimeter 4 to 5 of the same strip, being uppermost, should produce a successful infection.

COMMENT

The results of the foregoing experiments indicate that the virus particles of rinderpest are negatively charged when suspended in a solution the hydrogen-ion concentration of which approached the normal blood reaction; namely, pH 7.4. This was shown by the uniform infection produced in cattle and carabaos that received the injection of paper segments exposed to a virus suspension at pH 7.2. When suspended in a solution of pH 6.2, however, the virus particles were found to possess either a positive or negative charge, as was demonstrated by the success or failure to produce infection when susceptible animals were inoculated with the suspension prepared from segments of the same paper strip exposed to a solution of the above-mentioned hydrogen-ion concentration. At pH 5.2 the virus particles appeared to have a positive charge, since in all the experiments the animals injected with papers exposed to virus suspensions of this hydrogen-ion concentration remained unaffected.

The apparent delay in the incubation period in the reacting animals throughout the experiments—namely, first rise of temperature on the fifth to seventh day after inoculation—might be due in a measure to the minute quantity of virus present in the inoculated segments. Again, such factors as the partial adsorption of the virus particles by the paper and the virulence of the virus, not to mention the partial resistance of the animals to the injected dose, collectively might explain such retarded incubation. As demonstrated by Boynton(2) and confirmed by the author, the minimum infective dose of rinderpest blood in this laboratory is 3 cc of a dilution of 1: 10,000. However, animals inoculated with such a dose showed a rise of temperature on the third or fourth day after inoculation.

CONCLUSION

The virus of rinderpest carries a positive charge in a solution of pH 5.2; near the blood range, pH 7.2, the particles uniformly carried a negative charge; while at pH 6.2 they may either be positively or negatively charged, as shown by the success or failure of producing infection with paper segments exposed to a solution of such hydrogen-ion concentration.

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ILLUSTRATION

TEXT FIGURE

FIG. 1. Author's set up of the Bedson and Bland paper method for determining electric charge; *w*, wire line; *p*, blotting paper; *sl*, suspension level; *1*, *2*, *3*, and *4*, glass vials containing virus suspension in Sorensen's phosphate; *1*, at pH 5.2; *2*, at pH 6.2; *3*, at pH 7.2; *4*, at pH 8.2.

INDEX

[New names and new combinations are printed in **boldface.**]

A

B

C

D

E

F

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N

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S

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